BOTANICAL GAZETTE

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Contributions from the Cryptogamic Laboratory of Harvard University. XXXII.

Notes on cultures of Exobasidium Andromedæ and of Exobasidium Vaccinii.

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WITH PLATE VI.

Among the various species of Exobasidium there has been one described on *Andromeda ligustrina* characterized mainly by the large hollow distortions which it produces on its host. Peck, who is the authority for this species, has given the original description of it in one of his reports[1] and the few other references by different botanists are all brief or even limited to the citation of the name in local floras. Unlike *Exobasidium Azaleæ* Peck, which some consider a variety of *E. Vaccinii* (Fuckel) Woronin, *E. Andromedæ* Peck has never been questioned as a distinct species and this mainly on the character of the distortion it produces. It is true that the measurements of the spores as given by Peck are much larger than those of any other Exobasidium but in all the specimens examined by the writer, including those in exsiccatæ, no such large spores were found.

In order to determine something more about the nature of this fungus and to compare it with other species of the genus an investigation was begun at the suggestion of Professor Farlow with the intention of examining all of the species of Exobasidium available. Since it will be impossible for the writer to complete this work now, and since the results of the observations and experiments already completed are definite, though unfortunately somewhat incomplete, it has seemed best to publish, at the present time, what has been done.

[1] Report State Botanist N. Y. 26: 73.

The distortions caused by Exobasidium Andromedæ, which are much the largest of any caused by the Exobasidia, hang down as large, usually greenish, bag-like distortions from the smaller branches of the host, Andromeda ligustrina. As far as could be determined the distortions arise from the young buds, either leaf or flower buds, but usually the former. They are attached by a very small point and easily break off. In size the bags vary anywhere from five to six inches long by four across, to small distortions not over two inches in their longest diameter. The color, while often more greenish than other Exobasidia, sometimes is the characteristic pink or red that one sees in E. Vaccinii on Gaylussacia.

In structure the mature gall is hollow with comparatively thin walls which are supported by numerous more or less branched cords of tissue that radiate from the point of attachment and terminate on the inner surface of the wall. With the exception of these cords and a certain amount of loose tissue hanging to them, the fully grown distortion is quite empty, contrasting with the form of E. Vaccinii on *Rhododendron viscosum* commonly known as E. Azaleæ. In the young condition the distortions of E. Andromedæ are solid and almost succulent like those of the other form referred to.

The cords which traverse the interior of the gall are nothing more than the distorted vascular bundles to which hangs a certain amount of loose parenchymatous tissue. The cells of the latter are very much elongated and very thin walled. Sometimes they even branch (fig. 12), forming a mesh work of filaments, often of considerable extent. In the younger distortions this parenchymatous tissue is more solid, and it may be said indeed to represent the distorted leaf parenchyma, but, as the gall increases in size, the cells are torn apart and, ceasing to multiply, leave the interior of the distortion hollow. As far as the vascular bundles are concerned, while they are very much split up and twisted, the spiral ducts and other wood elements individually present no very abnormal appearance.

The wall, which in the mature specimens is really nearly all there is to the distortion, consists of a number of layers of rounded parenchyma cells, tightly packed near the surface and gradually merging into the elongated cells below (fig. 1). The epidermal cells themselves, while enormously increased

in number, retain their normal size, but the others are considerably enlarged. It is to the excessively rapid growth of the cells on the periphery and almost entire quiescence of those in the interior that the hollow character of the gall is due.

The hyphæ of the parasite are mainly located in the wall of the distortion but some are seen among the parenchyma cells which cling around the vascular bundles. They are very fine, not more than 1.5μ in diameter, and are much branched, but never seem actually to enter the cells. The basidia which arise from them push their way up in the usual fashion between the cells of the epidermis. They arise as outgrowths directly from the hyphæ, with which their connection may be easily demonstrated (figs. 7, 8, 9). In each basidium a well defined nucleus is seen and its division and the subsequent formation of the spores were not seen to differ at all from that described by Rosen[2] in other Basidiomycetes. For further details one should consult this article and also the papers by Wager.[3] Of the general course of the formation of the spores Woronin has given a description, which corresponds to the figures here shown (figs. 2–6). As in other Exobasidia the number of spores on a single basidium is not constant, varying usually from four to seven, while in rare cases two were observed.

As far as the writer has seen the spores do not differ materially from those of Exobasidium Vaccinii and are subject to as much variation. They have the same elongate, sometimes slightly curved shape and finely granular contents. The size as measured in the specimens examined is scarcely more than that of the spores of E. Vaccinii, being about 14–15μ long by 3μ wide. This does not correspond, it is true, to the published descriptions, which give the size as 22–25μ long. That the spores measured were mature there can be no doubt, for many of them had become divided after the manner of the ripe spores of Exobasidia. In the specimens of Exobasidium Andromedæ in Ellis[4] the longest spore obtained was 18μ but the majority were of the size already given.

In this connection attention may be called to a misprint in Saccardo's Sylloge Fungorum[5] and in Winter's Pilze[6] where

[2]Cohn's Beitræge **6**: 259.
[3]Annals of Botany **7**: 489. 1893.—**8**: 321. 1894.
[4]N. A. F.
[5]**6**: 664.
[6]Rabh. Krypt. Flora **1**[4]: 322.

the measurement of the spores of E. Vaccinii is given as 5–8μ. On turning to Woronin's paper,[7] to which both of these descriptions are referred, it is seen that the measurement given by him is 14–17 × 3μ.

Besides the basidiospores there are found certain forms of conidial fructification. The first form is like that described by other writers on Exobasidium Vaccinii and consists of small acicular spores borne on much branched hyphæ among the basidia. The conidia of the second form are larger and are borne singly on rather stout hyphæ not occurring with the basidia (fig. 11). In germinating both of these forms send out the small acicular secondary spores, like those produced in the germination of the basidiospores. The large hollow distortions are also found on other species of Andromeda. Specimens of an Exobasidium on *Andromeda floribunda* were sent me by Dr. W. C. Sturgis, collected by him in West Virginia, which resembles exactly in all respects the E. Andromedæ.

There occurs on Andromeda ligustrina another form of Exobasidium which closely resembles in general appearance the form figured by Woronin for E. Vaccinii[8] on *Vaccinium Vitis-Idaea*. A microscopical examination went further to confirm the impression of the similarity of these two forms. Figure 17 shows in a diagrammatic outline how a section of one of these distortions resembles Woronin's figures.[9] There is not a very great derangement of the leaf tissues; the palisade cells are somewhat enlarged and the parenchyma considerably thicker than is normal. The hyphæ and basidia are in no way different from those of E. Vaccinii, nor for that matter from those of E. Andromedæ. The close resemblance of this distortion to that of E. Vaccinii on one hand and the fact that it occurred on the same host as E. Andromedæ lead the writer to suspect a possible connection between these forms and cultures on living plants were undertaken to establish some certainty about this matter.

At first it was attempted to raise the spores on nutrient media and for this purpose cultures were made on agar with various substances for the nutritive base. In agar made with a decoction of young leaves of various ericaceous plants it was possible to get the spores to germinate and produce the small

[7] Verhandl. Nat. Ges. z. Freiburg 4: —. [Heft 4.]
[8] l. c. *pl. 1. figs. 3–8.*
[9] l. c. *pl. 2. figs. 1–4.*

fusiform secondary spores, such as Woronin[10] and Brefeld[11] figure, which kept on multiplying for some time and then finally refused to grow any more. Transfers of these on live plants produced no results, so the plan was abandoned for the time being and attention was turned to making inoculations on living plants from fresh material.

For the cultures on live plants healthy young specimens of Andromeda ligustrina, Rhododendron viscosum, and Gaylussaccia resinosa entirely free from any signs of Exobasidia were selected. The experiments were carried on at Newport, R. I., during the summer of 1894, the plants having been selected the previous year so that they would be well established. During the course of the experiments the plants were kept in a glass case excluded from accidental infection and separated from each other. Beginning on the 10th of July, and for a number of days following, infections were made on these plants with the spores of various Exobasidia.

The specimens of Exobasidium used were selected with great care, only perfectly fresh ones which were as far as possible removed from contamination with other spores being collected. As soon as picked they were placed in sterilized tin boxes and so kept until the inoculation was made. As an additional safeguard specimens were not taken from one locality only, but from as wide a range of territory as possible.

The first infections were made with Exobasidium Andromedæ the surface of the distortion being scraped with a sterilized platinum spatula moistened with a drop or two of boiled water. The spores thus obtained were examined in a sterilized Van Tieghem cell and afterwards transferred to the buds and young leaves of the plants to be inoculated. In this way several plants of Andromeda, Rhododendron, and Gaylussaccia of the species already named were infected. The plants thus prepared were then isolated in a moist chamber to await developments. This treatment was repeated on other specimens.

In the same way other plants of the same kind were inoculated with spores of Exobasidium Vaccinii and also duly isolated. The experiments on Rhododendron viscosum failed for some reason or other and we will turn our attention to those on the other plants which were more successful.

[10] l. c. *pl. 3. figs. 10–13.*
[11] Untersuch. aus d. Gesammtgeb. der Myk. 8: 9. *pl. 1. figs. 17–22.*

About ten days after the inoculation of the Andromeda plants with the spores of E. Andromedæ, there were noticed on the leaves faint discolorations, at first yellowish and later turning to pink. About five days later, the spots, which had considerably enlarged, began to show unmistakable signs of thickening, forming the familiar concavities in the leaves seen in other Exobasidia. In external form, and also in the matter of basidia and spores which will be discussed later, this distortion resembled precisely the leaf form on Andromeda ligustrina which had been collected previously. This indicates the fact that the Exobasidium Andromedæ which produces the large distortions of the young buds is identical with the leaf form found later in the summer.

The transfers on Gaylussaccia from the E. Andromedæ gave no definite results, perhaps owing to a number of mishaps to which these specimens were unfortunately subjected.

The infections made from E. Vaccinii now to be spoken of were, however, especially instructive. Those on Gaylussaccia developed in the way one would expect, the distortion on the leaf being of the kind collected out of doors near the end of the season. The most critical and interesting cultures, however, were those of this species on the Andromeda. The necessity of being especially careful with these cultures being evident, the writer adopted all possible precautions to avoid contamination. As in other cases, control specimens which had not been infected were kept under precisely similar conditions, without anything appearing on them. After about the same lapse of time as in other cases there appeared on the Andromeda leaves infected with E. Vaccinii, distortions very similar to those seen on Gaylussaccia and also to the leaf form on Andromeda which has already been described. Basidia and spores were produced from the mycelium concerning which more will be said later. That this distortion, so exactly similar to the one produced by the inoculations of the leaves of Andromeda with spores of the so-called Exobasidium Andromedæ, should be also formed by the growth of undoubted Exobasidium Vaccinii on the same host is very strong evidence of the identity of the two forms.

But before proceeding further in this discussion it will be well to speak of the microscopical appearances presented by these distortions, the description of which has been purposely left until now because of their great similarity. In their gen-

eral form all of these distortions resulting from the growth of artificial inoculations closely resemble the form of Exobasidium Vaccinii on Vaccinium Vitis-Idaea described by Woronin,[12] and the forms collected by the writer on the leaves of Andromeda and Gaylussaccia (figs. 17–20). Microscopically considered the character of the distortion on the Andromeda, from the infections of both the E. Andromedæ and the E. Vaccinii, is so precisely similar to that already described as collected in the field on the leaves of Andromeda that a description of them would be a mere repetition of the facts therein given. The mycelium, basidia, and spores likewise present no peculiarities which can separate them from those of E. Vaccinii. The spores measure $12–16 \times 3\mu$ and have the characteristic shape and appearance of those of the last named fungus (figs. 13–16).

Summing up the case, it is something like this. As has been shown above, aside from the form of the distortion, *Exobasidium Vaccinii* (Fuckel) Woronin and *E. Andromedæ* Peck cannot well be distinguished. The former can produce the same form of distortion on both Gaylussaccia and Andromeda and the latter has been made to produce a similar growth on Andromeda. Microscopically these forms do not differ. The natural conclusion is that these two species of Exobasidium are one and the same and the form producing large bag-like distortions on Andromeda should be considered a form of *Exobasidium Vaccinii* (Fuckel) Woronin.

It must be admitted that, at the time of writing, identity has not been completely established. To produce the typical form of E. Andromedæ with inoculations of spores of E. Vaccinii would be very desirable, but probably exceedingly difficult owing to the season of the year when the inoculations would have to be made. It ought to be perfectly easy however to grow distortions on Gaylussaccia from specimens of the so-called E. Andromedæ and it was the failure of these experiments which is most to be regretted.

The difference in size and structure of the distortions as a basis of specific distinction does not seem to have much weight. It is evident that the larger distortions are produced only in the early part of the year when the fungus attacks the young and sensitive tissue. In the forms ordinarily acknowledged to be Exobasidium Vaccinii there appears first the large distortion on Rhododendron viscosum formerly known as E. Azaleæ, and also on Gaylussaccia resinosa in the earliest

[12] l. c., p. 5. *pl. 11. figs. 1–6.*

formed distortions, whole shoots are transformed.[18] Later in the season the Exobasidium forms only slight local distortions on the leaves, and still later one finds forms which do not distort the tissues of the host plant at all, but simply form a scurf on the lower side of the leaves. The same succession is found in the forms on Andromeda down to the last mentioned, to which my attention was called by Dr. W. A. Setchell at Woods Hole, Mass., late in the month of August. It was also found up to early September in Newport, R. I. This form, which appears as simply slight whitish spots on the under side of the leaves, has not been definitely connected with the others as yet by means of cultures, but the spores and basidia are the same as those of the other forms on Andromeda.

This being the case it would appear that, in Exobasidium Vaccinii at least, the form and extent of the hypertrophy depends both on the host and the age of the tissues affected. The older tissues do not respond so readily to the stimulation of the parasite, and the result is a more local hypertrophy or none at all. Differences of these kinds may be commoner than is generally recognized, and where, in the simpler forms of fungi, the distortion plays an important part in specific distinctions only actual experiment with living cultures could determine whether two closely similar species are really distinct or not.

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EXPLANATION OF PLATE VI.

Fig. 1. Section of wall of distortion of Exobasidium Andromedæ on Andromeda ligustrina. × 210.

Figs. 2–9. Various stages in the development of the basidia and spores of E. Andromedæ. × 550.

Fig. 10. Mature and germinating spores of same. × 550.

Fig. 11. Conidial spores of same. × 360.

Fig. 12. Distorted parenchyma cells from the center of the gall. × 210.

Figs. 13–14. Basidia and spores from infection of Andromeda leaf with E. Andromedæ. × 550.

Figs. 15–16. Basidia and spores from infection of Andromeda leaf with E. Vaccinii.

Fig. 17. Outline of distortion produced by E. Vaccinii on Andromeda leaf. × 10.

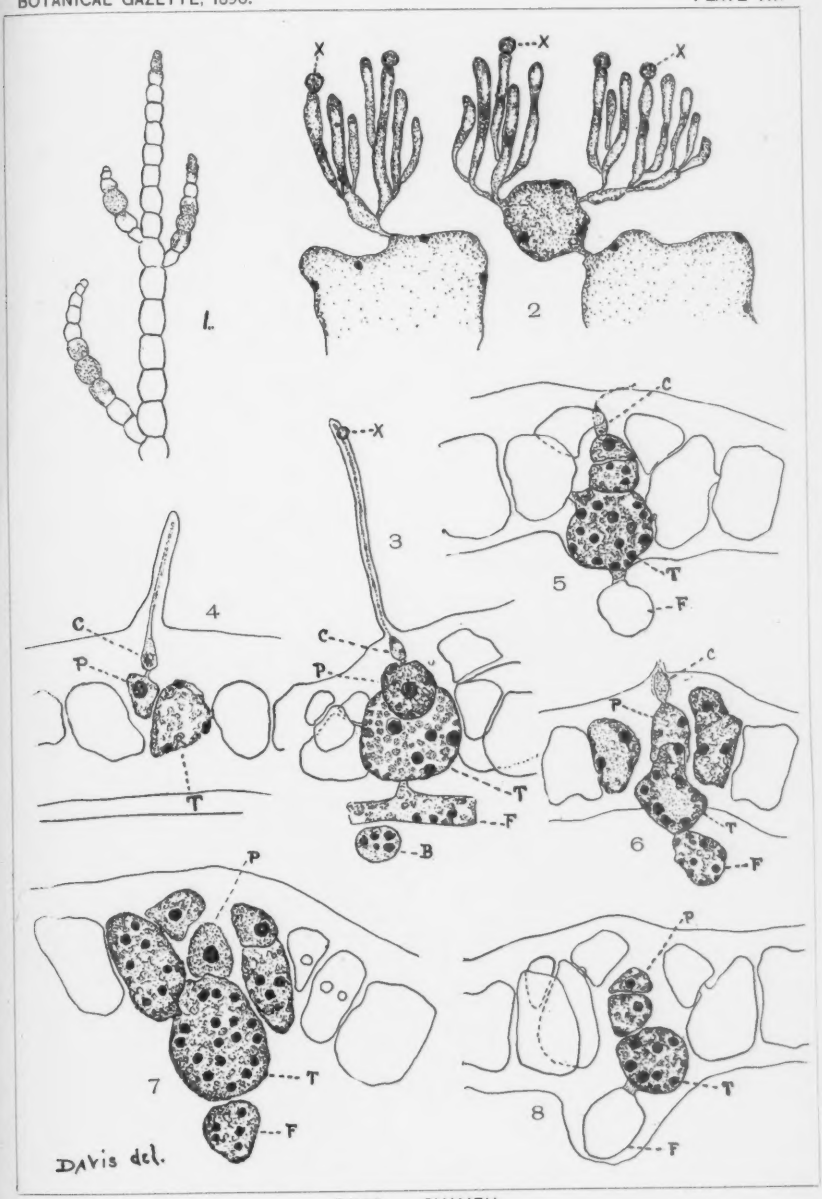
Fig. 18. Same produced by E. Andromedæ. × 10.

Fig. 19. Same collected in the field. × 10.

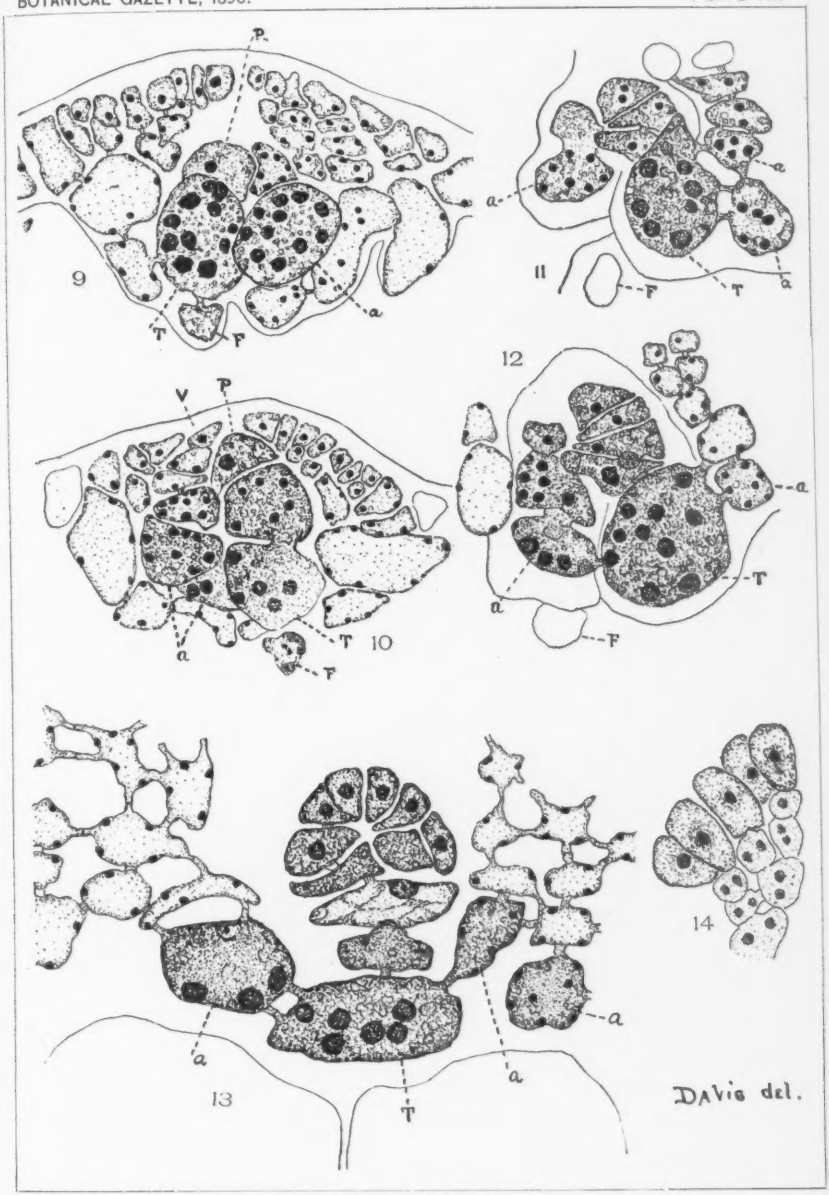
Fig. 20. Same of E. Vaccinii on Gaylussaccia collected in the field. × 10.

*** All of the figures reduced about ⅓ in reproduction. Figures 1–16 were drawn with the aid of an Abbé camera.

[18] The writer collected a form similar to this on Andromeda polifolia at Shelbourne, N. H., in June, 1894.



DAVIS on CHAMPIA.



DAVIS on CHAMPIA.

Contributions from the Cryptogamic Laboratory of Harvard University. XXXIII.

Development of the cystocarp of Champia parvula.

BRADLEY MOORE DAVIS.

WITH PLATES VII AND VIII.

Champia parvula (J. Ag.) Harv. is representative of a type of carposporic reproduction remarkable for the phenomenon of cell fusion which takes place previous to the formation of the glomerule of spores. This genus together with Chylocladia and Lomentaria form a group agreeing with each other, according to Hauptfleisch,[1] in the essential points of the development of the cystocarp. The steps in this process, as described by Hauptfleisch, are very interesting and, as the subject is complex, the writer thinks that he cannot better introduce the matter which treats of his own observations than by giving first a brief summary of the results obtained by the first investigator of the fruit development of these forms.

The following four paragraphs will then constitute a brief sketch of Hauptfleisch's conclusions:

(1) The procarpic branches (Carpogonäste) are found near the tips of the branches of the frond. Each procarpic branch is attached to an ordinary thallus cell and the latter is united to one of the internal filaments (Markfaden) that traverse longitudinally the interior of the hollow fronds. The procarpic branches consist of three or four cells (three in the case of Champia), the terminal one being the carpogonium and bearing a delicate trichogyne which projects through the outer wall of the frond.

(2) After or at the time of the formation of the procarpic branch there is developed an auxiliary cell (two in Chylocladia). An ordinary thallus cell, neighbor to the cell which bears the procarpic branch, becomes richer in cell-contents and then divides into an upper and a lower cell. The upper cell is the auxiliary cell.

(3) When the carpogonium is fertilized the trichogyne withers. The cells of the procarpic branch then gradually

[1] Hauptfleisch, Die Fruchtentwickelung der Gattung Chylocladia, Champia, und Lomentaria. Flora **75**: 306. 1892.

fuse together, beginning at the carpogonium end and there results a large "fusion cell."

In Chylocladia and Champia the fusion of the cells of the procarpic branch extends so far that it finally includes the cell which bears the procarpic branch. The very large "fusion cell" then unites with the auxiliary cell which usually sends out a process for the purpose and this auxiliary cell becomes the "central cell" from which the glomerule of spores is developed. Slight modifications of the process as stated above are found in some species, but this is the phenomenon as described for Champia parvula and the main principle of a union between a fusion cell and an auxiliary cell is true in all cases. Hauptfleisch states that in *Chylocladia kaliformis* the fusion cell contains one large nucleus resulting from the union of all the nuclei in the cells of the procarpic branch. The auxiliary cell also contains a single nucleus and when the fusion cell unites with it the two nuclei approach each other and coalesce.

In Champia parvula the hook-shaped process from the fusion cell, that is put out towards the auxiliary cell, contains a single large nucleus.

(4) The wall of the cystocarp is formed in the same manner in all the genera.

Filaments spring from the cells neighboring those concerned in the process of fertilization and spore formation, and by their growth and branching the wall of the cystocarp is formed. The interior of the young cystocarp is more or less filled with a loose network of filaments that are pushed against the side of the sporangium wall by the development of the glomerule of spores.

The material with which the writer worked was collected at Woods Hole, Mass., during the summer of 1894. The observations were made chiefly from sections, as it was not easy to crush out preparations, particularly of older stages of the fruit. If care be taken the tissues of the plant may be imbedded in paraffin and sectioned without material shrinkage of the cells, such serial sections being very desirable for the study of certain stages. The writer also employed a method of sectioning suggested by Mr. W. J. V. Osterhout, in which the tissues were frozen in a solution of gum arabic. Such sections were mounted in glycerin, the method proving satisfactory and a time-saver. The specimens for the most part were stained *in toto* with Mayer's acid haemalum.

A number of antheridial plants were found during the summer, and in one instance the same plant bore both antheridial and cystocarpic branches. The antheridia form patches on the frond, indefinite in extent and variable in position, sometimes appearing as caps at the ends of the branches but more often as bands around older portions of the frond (fig. 1). The structure of the antheridium is somewhat similar to that of the genus Lomentaria described by Mr. Webber.[2] The very small antherozoids are borne singly on the tips of short filaments, which arise in branching clusters from the thallus cells. Fig. 2 shows three of these clusters and there it may be seen that each cluster consists of several short filaments, the younger being branches from the older.

We must refer at the outset to an interesting point in the structure of the older cells of the frond. The young cells at the apex of a branch contain only one nucleus but cells somewhat removed from the growing point are multinucleate. This character is very striking and is shown in most of the figures (see figs. 2, 7, 9, 14, etc.).

The writer has observed similar conditions in the older cells of several genera of Florideæ, for example Callithamnion, Griffithsia, Spermothamnion, and Polysiphonia, and in some cases, as in the older cells of Griffithsia, the number of nuclei becomes very large indeed. Apparently a multinucleate structure of the older cells of Florideæ is likely to prove a very general fact.

My preparations have shown that the procarpic branch may consist of two or three cells. It is a small structure (figs. 3 and 4), and is always attached to one of the large thallus cells. As a rule the thallus cell (*t*, in the figures) is joined to one of the internal filaments, *f*, that traverse the frond, but this is not always the case, and procarps and young cystocarps have been found quite removed from it.

The trichogyne is a very delicate structure arising from an extremely small cell, the carpogonium, *c*. The whole structure is so small that even under such high magnification as 1,500 diameters, it is very difficult to determine the structure of its cell contents. There is granular matter in the carpogonium (fig. 4) that stains rather deeply and may be nuclear substance.

In one case (fig. 3) a trichogyne was found with what ap-

[2] Webber. On the antheridia of Lomentaria. Ann. of Bot. **5**: 226. 1891.

peared to be an antherozoid at its tip, but the trichogyne was so very delicate and the antherozoid so small that the relation between the two structures could not be satisfactorily studied. Even if such stages as are shown in fig. 3 were common their small size seems to the writer to preclude the possibility of determining what takes place at the time the antherozoid is applied to the trichogyne.

The single cell or each of the two cells of the procarpic branch below the carpogonium contains a single well defined nucleus. The thallus cell (fig. 3 and 4, *t*) to which the procarpic branch is attached is larger and contains rather denser cell-contents than the neighboring cells of the frond, but like them is multinucleate. It is probably always united to neighboring thallus cells by strands of protoplasm, although such connections may not always appear in sections which are necessarily cut in a single plane. The attachment to the internal filament is usually by a broad strand of protoplasm, and not infrequently one of the bulb cells found along the internal filaments occurs opposite this point (fig. 3, *b*).

The trichogyne withers quickly and the upper portion disappears very rapidly. The swollen portion at the base (carpogonium) remains somewhat longer (figs. 5 and 6) but takes the stain very faintly and finally disappears, and the lower cells of the procarpic branch are left attached to the thallus cell. The condition of the procarp is then either that shown in fig. 7 or fig. 8; that is, it consists of one or two cells, each probably containing as a rule only a single nucleus, attached to a thallus cell which is multinucleate. At this time the protoplasm of the thallus cell and of the cells of the procarpic branch above has become very dense and stains heavily, so that these stages appear very conspicuous in the sections. The nuclei in the thallus cell multiply in number and increase in size at this period when the cell is becoming gorged with protoplasm.

At this point we had best consider the changes which take place in the tissue around the cells of the procarp after the trichogyne has disappeared. The contents of the thallus cells directly around that which bears the procarpic branch gradually assume a different character. The protoplasm becomes very much denser and the nuclei increase in number and grow larger in diameter. These thallus cells are evidently what Hauptfleisch has called the auxiliary cells. There are fre-

quently several of them but there may be only one. They are exactly similar to the thallus cell, bearing the procarpic branch, in the appearance of their cell contents, and we can only identify the latter by its attachment to the procarpic branch on the outside and as a rule to an internal filament on the inside of the frond.

Coincident with the gradual change in the character of the cell-contents which precedes the differentiation of the auxiliary cells, a number of short filaments begin to grow up over the procarpic branch. The filaments arise from the thallus cells around the procarpic branch, meeting at a point above it, and form a sort of dome over that structure. This is the beginning of the wall of the cystocarp. In the early stages it is perfectly evident that these filaments arise from ordinary thallus cells which afterward become auxiliary cells. So the auxiliary cells are not special structures developed separately from the vegetative tissue, but they are cells of the vegetative tissue directly around the procarp that become modified as to their cell-contents in a manner quite similar to those of the procarp.

An examination of the figures will perhaps serve to make the points considered in the last two paragraphs more plain. In several of the figures previously described (figs. 5, 6, 7, and 8) it will be noticed that the thallus cells on each side of the procarp have given rise to small cells above which bend over towards the procarpic branch. These with other cells, which are developed later, become the apical cells of a complex system of branches that form the wall of the cystocarp.

Fig. 9 is of a stage not very different from fig. 7. Here the wall of the cystocarp has begun to develop, but the conditions of the procarpic cell, *p*, and the thallus cell which bears it, *t*, are not materially changed except that they are larger and their nuclei much more prominent. On the right hand side of the figure is an auxiliary cell, *a*, very similar in appearance and structure to the thallus cell which bears the remains of the procarpic branch. Above the auxiliary cell is another cell rather dense in contents which is probably about to change into an auxiliary cell.

Fig. 10 illustrates a case in which the procarpic branch was originally composed of two cells besides the carpogonium and trichogyne. The thallus cell, *t*, which bears the procarpic branch is so cut that only a portion appears in this section.

Above it are the cells of the procarpic branch and on the left are three auxiliary cells, two at the side and one somewhat behind the others. The figure is especially interesting because it is evident that the vegetative branch, *v*, is directly continued from the two auxiliary cells at the side.

Figs. 9 and 10 do not give a correct idea of the great increase in size of the auxiliary cells and the cells of the procarp at this stage of development, for the magnification is much less than in figs. 6 and 7.

The writer has never observed any evidence that the cells of the procarpic branch ever fuse with each other or with the thallus cell which bears them. After the withering of the trichogyne the cells increase in size and the strands of protoplasm connecting them become much wider, but the cell-outlines remain quite distinct and the nuclei entirely separate. There is no union of nuclei into one large fusion nucleus. The thallus cell bearing the procarpic branch continues in its multinucleate condition. Each cell of the procarpic branch contains one nucleus which may afterwards fragment into several.

The auxiliary cells always contain in the beginning a number of nuclei and in the writer's preparations nothing was ever observed that would indicate a later union into one fusion nucleus; they always remain multinucleate.

However, some very interesting cytoplasmic disturbances take place. The thallus cell bearing the procarpic branch sends out many protoplasmic processes that unite with the auxiliary cells directly adjoining it, sometimes two or three processes with the same cell. In a like manner the auxiliary cells unite with one another and with the vegetative cells around them. This cytoplasmic activity occurs while the cystocarp is developing, but the position and number of the nuclei in the cells are apparently not affected by the formation of this net-work of fused cells. Fig. 11 illustrates an instance where the thallus cell, *t*, is connected by two strands of protoplasm with the auxiliary cell, *a*, and a similar condition is shown on the left hand side of fig. 13. In fig. 13 the reader will also observe how general is the cytoplasmic union of cells in the loose tissue around the young cystocarp. It should also be noted that the cytoplasmic fusion processes are smaller than the nuclei in the cells directly concerned with the development of the cystocarp.

The development of the favellæ of spores now remains to be considered. We must start with stages such as are shown in figs. 9 and 10. It will be remembered that at this stage the trichogyne and carpogonium have entirely disappeared so that the cell lettered *p* in these two figures is the one directly under the carpogonium. This cell gives rise to the cystocarp. By several transverse divisions, which are usually somewhat oblique, it forms a short branch consisting of four or five cells, two stages of which will be seen in figs. 11 and 12. The branch is greatly bent to one side in later stages and then oblique walls are formed across the upper segments in a very irregular manner, and there results a compact mass of cells divided up into a number of lobes. The entire young cystocarp is really a very complex set of filaments consisting of angular and irregularly shaped cells, but this structure is not readily shown in sections. The cells at first contain each a single nucleus, but when the cystocarp is mature it is apparent that the spores are borne on the ends of short branches (fig. 14) whose cells are multinucleate although each spore is uninucleate.

As the cystocarp arises from the cell of the procarpic branch just below the carpogonium, this is the place where we should expect to find cross fusion with auxiliary cells if such exists. The writer has observed no specimens which would indicate that an auxiliary cell ever completely fused with any of the cells directly concerned with the development of the cystocarp. Nothing was ever seen that could be compared with the "central cell" of Hauptfleisch. It is true that auxiliary cells are clustered around the cells of the young cystocarp, and it would be very easy for them to unite by protoplasmic processes, but the writer saw no clear evidence of such cytoplasmic fusion, much less of any nuclear disturbances. In some cases the cells of young cystocarps have been quite removed from auxiliary cells (fig. 14) and it was quite evident that no fusion had taken place; but when such cells are close together the protoplasm is frequently brought into such close proximity as to make it very difficult to decide the question of cytoplasmic fusion.

What is the cause of the very general cytoplasmic union of the cells at the base of the cystocarp? The phenomenon begins after the trichogyne has disappeared and the procarp has presumably been fertilized. It is concerned with the

thallus cell which bears the procarpic branch and the auxiliary cells. In all these cells the protoplasm becomes very much denser and the nuclei increase greatly in size in marked contrast to the ordinary vegetative cells of the thallus. The nuclei do not fuse. It has been suggested by several investigators that cytoplasmic activity of this nature is for nutritive purposes and the writer is inclined to believe this to be true of Champia.

The auxiliary cells are then cells in the neighborhood of the procarpic branch whose protoplasm has changed in character in a similar manner to the cell contents of the latter structure. They are not specially developed organs of the frond but are at first ordinary vegetative cells at the base of the filaments that later form the wall of the cystocarp. They vary in number and they vary in the degree in which their cell contents have been modified.

How is the procarp fertilized? Unfortunately the small size of the trichogynes and antherozoids presents a very serious obstacle to the study of this point. The conditions are further complicated by the poorly defined character of the nucleus in the diminutive carpogonium and because the trichogyne withers very early and completely disappears together with the carpogonium. To explain the facts according to present accepted views of the nature of the sexual act it must be supposed that the fertilizing substance, presumably nuclear matter, passes through the trichogyne and carpogonium into the cell below. Such complexity of conditions is quite unusual for the sexual act and presents great difficulties to a clear understanding of the subject and these difficulties are made more emphatic by the insignificant appearance of the trichogynes. The trichogynes resemble somewhat degenerate cells, quite lacking the clear well defined cell structure which we usually expect of sexual elements.

University of Chicago.

Explanation of Plates VII and VIII.

Preparations stained with Mayer's acid haemalum. All figures sketched with Abbé camera and lettered as follows: *a*, auxiliary cell; *b*, bulb cell; *c*, carpogonium; *f*, internal filament; *p*, cell of procarp just below carpogonium; *t*, thallus cell bearing procarp; *v*, developing wall of cystocarp; *x*, antherozoid. Figure 1 magnified about 5 diameters; figures 2–8 about 730 diameters; figures 9–13 about 530 diameters; figure 14 about 260 diameters.

PLATE VII.

Fig. 1. Portion of frond showing distribution of antheridia.
Fig. 2. Section of frond with antheridial filaments arising from the thallus cells; *x*, antherozoids.
Fig. 3. An adult procarp attached to an internal filament; *x*, antherozoid.
Fig. 4. A procarp showing granular matter, which may possibly be a nucleus, at base of carpogonium.
Fig. 5. Procarp with withered trichogyne; two cells between carpogonium and thallus cell.
Fig. 6. Procarp with withered trichogyne, one cell between carpogonium and thallus cell.
Fig. 7. Trichogyne and carpogonium entirely gone, one cell of procarp, *p*, above the thallus cell, *t*.
Fig. 8. Trichogyne and carpogonium entirely gone, two cells of procarp above the thallus cell.

PLATE VIII.

Fig. 9. Procarp with one cell above the thallus cell; auxiliary cell at the right; wall of cystocarp beginning to develop.
Fig. 10. Procarp with two cells above the thallus cell; auxiliary cells at the left; wall of cystocarp developing.
Fig. 11. Young cystocarp.
Fig. 12. Young cystocarp, next stage to figure 11.
Fig. 13. Half matured cystocarp.
Fig. 14. Group of ripe spores.

Notes on the flora of Chicago and vicinity. II.[1]

E. J. HILL.

CEANOTHUS OVATUS Desf.—This has recently been found in two localities near the shore of Lake Michigan, Edgemoor and Wilsons, Lake co., Ind. The nearest place where it is recorded as occurring elsewhere is in Winnebago co., Ill., or not far from Beloit, Wis. Three or four localities in the northern part of the southern peninsula of Michigan are mentioned, and according to the recent Catalogue of Ohio Plants by Kellerman and Werner it is found, though rarely, in the northern part of Ohio. Its distribution in the lake region is therefore peculiar, since the stations in Indiana are isolated, and distant from those of Illinois, Michigan and Ohio.

THASPIUM PINNATIFIDUM Gray.—I came across this plant in 1870 growing by the banks of the Kankakee river near Waldron, Kankakee co., Ill. It was at the time confused with *T. barbinode*, a specimen of the former being taken in flower and placed in my collection with one of the latter in fruit, as both grew in the locality. When more carefully examined some years afterward the two did not accord very well in appearance, but the lack of fruit and removal from the neighborhood did not permit a definite determination. In the summer of 1894 I found a Thaspium at Momence, Ill., whose fruit differed from that of T. barbinode. It was taken from the bank of the Kankakee, about ten miles above the former locality. Another fruiting specimen was obtained from Momence the past season. They have the characteristic fruit of T. pinnatifidum, all the ribs being winged, three of them being narrow. The leaves are somewhat intermediate between those of this species and T. barbinode. The leaflets are, however, usually much smaller and differently cut and divided into oval or oblong segments. T. pinnatifidum has hitherto been given as a plant of the barrens and mountains of Kentucky, Tennessee and North Carolina. Careful inspection of plants may locate it in places between the Kankakee river and this southern range, and forms may be found which will closely connect the two.

ARENARIA PATULA Michx.—This little sandwort has in part

[1] For the first paper see BOT. GAZ. **17**: 246. Ag. 1892.

a similar distribution and history. Originally described by Michaux with a habitat "in rupibus circa *Knoxville*,"[2] it was afterwards discovered in Kentucky by Dr. Short, and in the mountains of Virginia by Prof. Ruffner, and traced to Arkansas and Texas by Nuttall, Dr. Pitcher, Drummond and others (as *A. Pitcheri*). About 1870 Prof. H. H. Babcock detected it on the limestone formations of the Des Plaines river at Riverside just west of Chicago.[3] It occurs in considerable abundance in some localities of limestone within the city limits near Windsor Park and on Stony Island, and also beyond them at Lamont on the Des Plaines. It is reported from one locality, Tippecanoe co., Ind.,[4] between these stations in Illinois and its southern range.

THASPIUM BARBINODE Nutt.—This quite often has puberulent fruit, so much so that the figures of the fruit given in Coulter and Rose's "Notes on the Umbelliferæ of the United States,"[5] though true as to the wings, do not cover these cases. This is specially the case with plants on the opposite shore of Lake Michigan at Benton Harbor, Mich. In these the intervals of the ribs are strongly puberulent with short, blunt hairs, much as in T. pinnatifidum.

ECHINACEA ANGUSTIFOLIA DC.—Found on a small prairie east of Durham, a station on the L. S. & M. S. R. R., in Laporte co., Ind. As but a few plants were seen beside the road-bed it may possibly be an introduced plant, though more probably native, as such survivals are found in railway enclosures within cultivated districts. The range of the species is rather from Wisconsin and Illinois west and south, but it has been found as far east as Keweenaw co., Mich., about the same distance east as this station in Indiana. The farthest east I had previously seen it was on prairies east of Kankakee, Ill.

HELIANTHUS ANNUUS L.—The introduced plant native at the west was reported in my previous article as growing in the dump from stock trains west of the city in 1891. The following year it had appeared as a weed under the same conditions of growth along railroads east of the city at Roby, Ind., and is now well established in this locality by the shores of Lake Michigan.

[2] Flora Bor. Amer. **1**: 273. 1803.
[3] Flora of Chicago and vicinity. The Lens **1**: 23. 1872.
[4] Catalogue of the plants of Indiana by the Editors of the BOT. GAZ. 1881.
[5] BOT. GAZ. **12**: 136. *pl. 5. figs. 59, 60.* Je. 1887.

MYOSOTIS LAXA Lehm.—The range of this plant is given in the last edition of Gray's Manual as "Newf. to N. Y." Specimens of a Myosotis sent for identification some years ago from Painesville, Ohio, led me to expect its presence there, and the recent Catalogue of Ohio Plants by Kellerman and Werner mentions it as "frequent in marshes and wet places in northern Ohio."[6] Last summer I found it in abundance in the wet ground bordering the Calumet river near Dune Park, Porter co., Ind. The discovery of this plant in a region that had been quite well explored botanically might indicate that it is an introduction. If a recent comer it had better be considered an escape from gardens, being cultivated for *M. palustris*, of which it has been made a variety by some. Residents to whom the plant was shown called it Forget-me-not. But it is more probably a native that had been overlooked, like some others mentioned in this article. I have found it in the St. Lawrence basin by the Saguenay river, and its range in Canada is given by Macoun as from the lower St. Lawrence to the vicinity of Buffalo, N. Y., so that its connection with the eastern flora is not difficult to make out. There is still much to learn about the details of the geographical distribution of some of the less common plants, and apparent gaps may yet be filled.

CELTIS OCCIDENTALIS L. var. PUMILA Gray.—In 1893 a couple of small hackberries were found near Millers, Ind. They were nearly out of flower (June 6), but were identified as above. They grew near the shore of Lake Michigan, and being but three or four feet high they could not again be found in the wilderness of shrubs and shrubby oaks which characterized this section of the dune region. Last year I came across several more about two miles from the former place, and in a locality not so difficult to keep in mind. This was along the Grand Calumet and near its mouth now silted up with sand. Some of them were large examples of the shrub, the largest stems three inches in diameter, and fifteen feet long. Several ascending stems usually spring from the same root and form clumps about as broad as high. They are very scraggy, the branches thickly set with short, stiff, sub-spinous twigs two or three inches long. They are caused by the winter-killing of the tips, so that the bush, especially when stripped of leaves, resembles a thorn-bush. The habit is so unlike that of the common hackberry, a tree not infre-

[6] Geology of Ohio 7²: 112. [Botany.]

quent in some sections about Chicago, that it is hardly recognized as of the same species. The pointed leaves are usually narrower than in the arboreous hackberry, from narrow ovate to ovate-lanceolate, many of them falcate. Occasionally they are broad and short, both forms occurring on the same stem. The upper third or half of the leaf may be sharply serrate, especially when the leaves are young, but they are often nearly entire, or with a few callous tipped teeth mainly on one margin near the apex. The mature leaves are rather thick and firm in texture. The fruit is globose or a little prolate, one-fourth to one-third of an inch in diameter. When ripe it is of a dark brownish purple color. The flesh is orange colored as well as the stone and seed. There are some features in which it resembles *C. Mississippiensis* Bosc, as in the size of the fruit. This variety of the hackberry is a south Atlantic species, ranging westward, according to Sargent's Silva of North America **7:** 69, to Missouri, Colorado, Utah and Nevada, and growing on the rocky banks of streams. Here it occurs in the sand of the dune region, near the shores of the lake. I have traced it for a distance of three miles.

ALNUS GLUTINOSA Willd.—This is used in some parts of the city as a shade tree, and has become naturalized in some places south of Jackson Park. It has spread into the wet land, making thickets of low trees and bushes like the common alders. They fruit when at the height of four to six feet.

POTAMOGETON DIVERSIFOLIUS Raf. (*P. hybridus* Michx). —The point nearest the city where I have seen this is Laporte, Ind., where plants grow in shallow pools by the borders of Pine Lake.

P. INTERRUPTUS Kitaibel. Two localities are given for this pondweed in Morong's Naiadaceæ of North America:[7] Manistee, Mich., and the Channel islands, St. Mary's river, Mich. I first came across this plant at Manistee in 1880, near the mouth of the Little Manistee. In 1881 I found it at the latter place. These were mentioned in a contribution to the BOTANICAL GAZETTE in 1881.[8] Later in the same year it was found in the Calumet river at South Chicago. In Higley and Raddin's Flora of Cook county, Ill., and a part of Lake county, Ind.,[9] this is mentioned as a broad leaved form

[7] Mem. of Torr. Bot. Club, **3:** 54. 1893.
[8] l. c. **6:** 262. 1881.
[9] Bull. of Chicago Acad. of Sci., **2:** 124. 1891.

of *P. pectinatus* but is made identical with those from Michigan, which Dr. Morong subsequently published as *P. interruptus*. Its strong resemblance to *P. flabellatus* Babington, which Dr. Morong makes a synonym of this species, was quite apparent from the first. These three localities seem to be the only undoubted ones from which it has been obtained, though from specimens collected in the Au Sable river, Frankfort, Mich., it may also be present there. The lack of mature fruit, which I have never been able to obtain, leads to considerable difficulty in distinguishing it from forms of P. pectinatus. The locality at South Chicago was, soon after its detection there, destroyed by dredging and the building of docks, and with it the hope of getting ripe fruit late in the season near at home. I have examined them as late as the twenty-second of October without finding it. The species is no doubt extant in other localities, especially in northern Michigan.

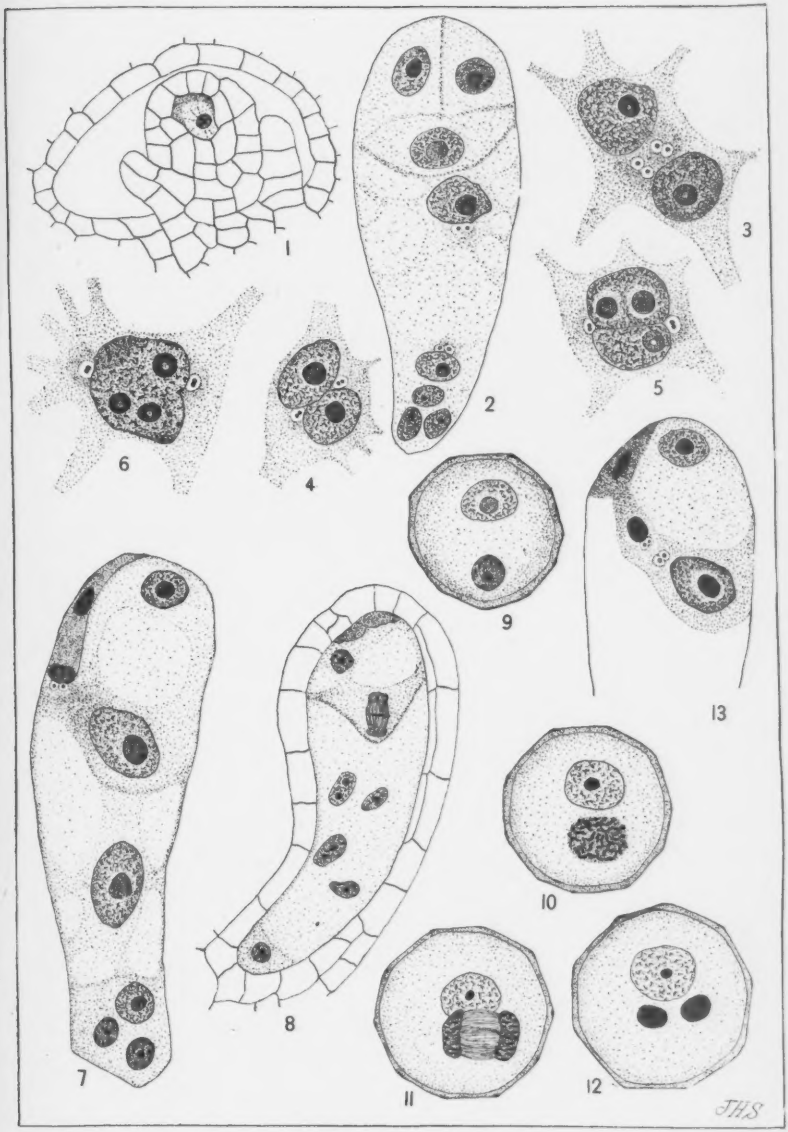
ELEOCHARIS MELANOCARPA Torr.—Found in 1894 on the sandy borders of Pine lake, Laporte, Ind. Soon after it was detected at Dune Park, where it is quite frequent. It has been considered a maritime plant, its range being near the sea from Plymouth, Mass., to Florida. At Dune Park it grows in the sand bordering sloughs.

SCIRPUS TORREYI Olney.—This was noticed at the same time in sloughs at Dune Park, but is rare. It has not before been reported in Indiana, nor do I know of its presence in Illinois. It is so nearly like *S. pungens* in outward appearance as to be easily overlooked, but in pulling a plant from the wet soil one readily sees the difference.

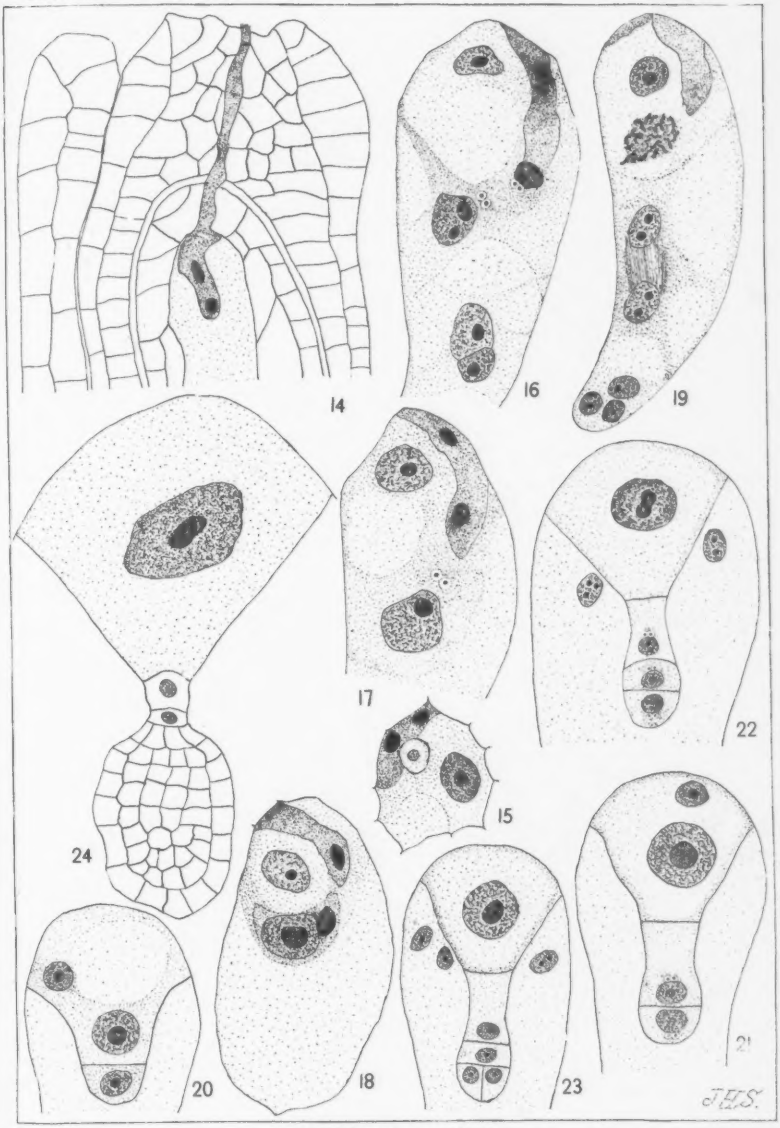
HOMALOCENCHRUS LENTICULARIS Scribn. (*Leersia lenticularis* Michx.).—South bank of Kankakee river, Kankakee, Starke co., Ind. I do not find it reported elsewhere from Indiana. The locality is but a little north of its northern range in Illinois, Henderson and Peoria counties (Patterson), and is doubtless near its northern limit in Indiana.

EQUISETUM ROBUSTUM Braun.—Bluffs of St. Joseph river, near St. Joseph, Mich. Specimens of this scouring rush were obtained in 1894 growing in the springy soil of the steep banks of the river at a place locally known as Royalton Heights. This is farther north than I find it given elsewhere. In Illinois it occurs from Peoria southward. Its more usual home is toward the Ohio river.

Chicago, Ill.



SCHAFFNER on ALISMA.



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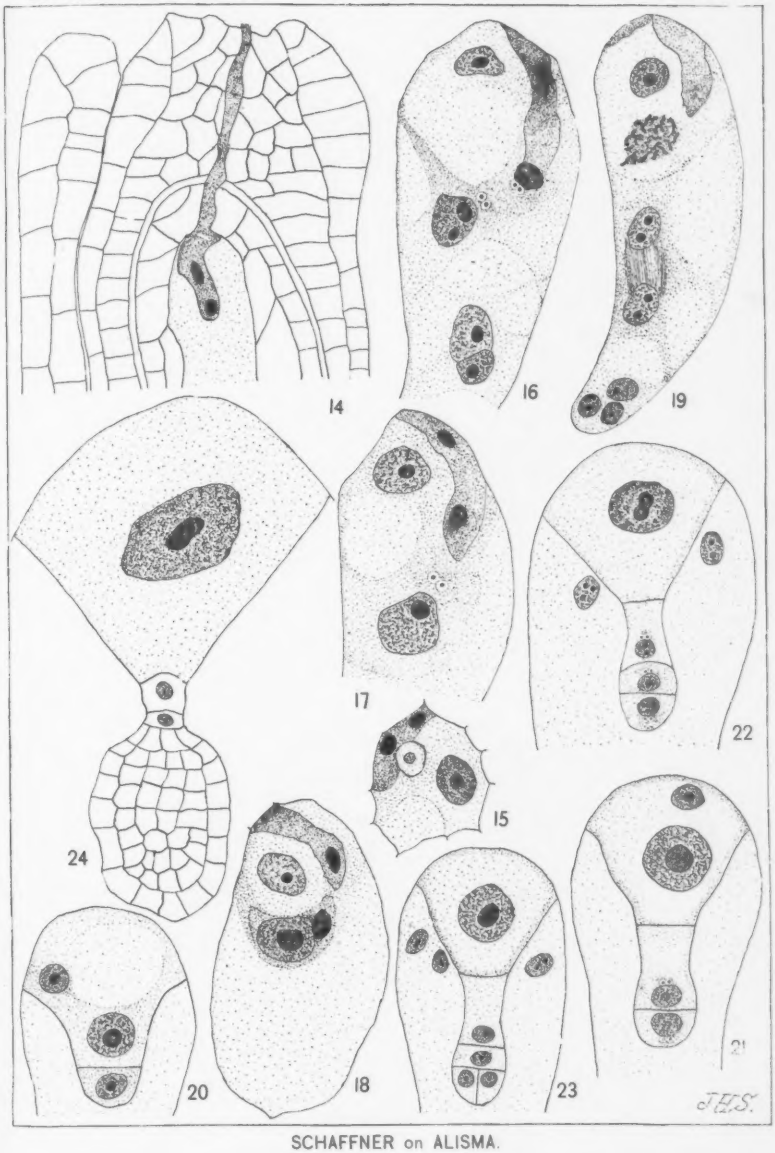


SCHAFFNER on ALISMA.

The embryo-sac of Alisma Plantago.[1]

JOHN H. SCHAFFNER.

WITH PLATES IX AND X.

The embryo-sac of angiosperms still presents an inviting field for research. There seem to be many variations in the general processes which occur in it, and most of the observations on the finer structure need confirmation. Especially in regard to the real meaning of the conjugation of the polar nuclei, and what is represented by the antipodal cells, does there still seem to be much obscurity. It was for the purpose of making a preliminary study with a view for further investigation later, that the following work on the embryo-sac of Alisma was undertaken.

The embryo-sac of *Butomus umbellatus* L. was described by Vesque[2] in 1878, and later by H. Marshall Ward,[3] who also made a few observations on *Alisma Plantago* L., which agreed in general with those on Butomus. The development of the embryo of Alisma has become well known through the investigations of Hanstein.[4] Guignard[5] studied the minute processes which occur in the embryo-sac of Lilium Martagon and described the conjugation of the centrospheres of the sperm nucleus and oosphere. He observed the same process during the union of the two polar nuclei. These observations have hitherto not been confirmed.

My material was collected on July 30, 1895, and killed in a chrom-acetic acid solution: acetic acid 0.7 per cent., chromic acid 0.3 per cent., water 99 per cent. All the sections were made by imbedding in paraffin and staining on the slide. The principal stains used were anilin-safranin and acid fuchsin. The work was carried on under the direction of Professor

[1] Contribution from the Botanical Laboratory of the University of Michigan.

[2] Développement du sac embryonnaire des phanérogames angiospermes. Ann. des Sci. Nat. Bot. VI. **6**: 237–285. 1878.

[3] Contributions to our knowledge of the embryo-sac in angiosperms. Jour. Linn. Soc. Bot. **17**: 519–546. 1880.

[4] Die Entwicklung des Keimes der Monokotylen und Dikotylen. Botanische Abhandlungen aus dem Gebiet der Morphologie und Physiologie **1**: —. 1870. [Bonn.]

[5] Nouvelles Etudes sur la fécondation, etc. Ann. des Sci. Nat. Bot. VII. **14**: 163–296. 1891.

F. C. Newcombe, to whom I here express my sincere thanks for kind assistance rendered in various ways.

Development of the embryo-sac.

The young ovaries arise as protuberances around the edge of the flattened receptacle, and soon there appears in the interior of each one a schizogenetic cleft on the inner side of which the nucellus is formed. This cleft increases in size quite rapidly by enlargement and division of the cells of its walls, thus making room for the developing nucellus. When the nucellus has obtained some considerable size, there can be seen in it a large hypodermal cell which appears to be the archesporium. No division of this cell into two was observed, but at a later stage the large macrospore shows the remains of a former cell at its micropylar end (fig 1.) which is the tapetal cell. The ovule soon becomes anatropous. The integuments are two in number, but on the side of the funiculus the outer one is generally not developed. As the embryo-sac increases in size the ordinary divisions of its nucleus take place. First it divides into two, one of the daughter nuclei passing to the upper and the other to the lower end of the sac, after which each of these, by two successive divisions, produces four nuclei, thus making the typical eight-celled embryo-sac (fig. 2). Often only two nuclei could be distinguished at the base of the embryo-sac. But as it is quite narrow at this end the missing ones may have been in the adjacent sections, and there indistinguishable from the nuclei of the surrounding tissue.

All the nuclei except the three antipodal nuclei are comparatively large in size and each one contains usually one large nucleolus, but sometimes two (fig. 2). The two synergidæ lie side by side. They are surrounded by granular cell walls, and their nuclei are either spherical or ellipsoidal. They stretch across the entire upper end of the sac, and just beneath them the oosphere is suspended in a dense mass of cytoplasm. Its nucleus is usually ellipsoidal in shape. Beyond the oosphere and lying free in the cytoplasm is the upper polar nucleus. Its centrospheres usually lie on the under side, though in a few cases they were on the side toward the oosphere. The cells in the antipodal region simulate the arrangement in the egg-apparatus. There are two small nuclei lying at the base; and beyond them is the third antipodal

nucleus. This nucleus always stains a very dense red with anilin-safranin and its centrospheres are usually very prominent. It would by its peculiar appearance suggest that it may be the homologue of the oosphere. These three nuclei are not surrounded by any definite cell-walls, but the cytoplasm in which they are imbedded is rather dense. Immediately beyond the antipodal cells is the lower polar nucleus. This is much the largest nucleus in the antipodal region, and it contains usually one large nucleolus. Its centrospheres lie on the upper side, toward the upper polar nucleus.

Conjugation of the polar nuclei and their centrospheres.

The two small granules lying on one side of the resting nucleus are now generally called centrospheres by English writers, and this term is here employed as the most appropriate. The dense centre is appropriately designated by the usual term "centrosome," while "attraction-sphere" will be used for the hyaline layer surrounding this.

I might here state that all my observations on these bodies made heretofore[6] have been more fully confirmed during the present investigation. The centrosphere is composed of a dense central body, which appears to have a granular structure, and an outer hyaline layer, composed of a highly refractive substance, which takes little or no stain, but under favorable circumstances shows a delicate radiate structure. The whole structure is limited from the surrounding cytoplasm by a definite granular layer, which is easily distinguished and may appropriately be called a membrane. The centrospheres in the embryo-sac are much more prominent than in the surrounding tissues, and in this respect they agree with the nuclei.

As stated above, when the two polar nuclei begin to travel toward each other, they have their centrospheres so situated that they precede the nuclei; however, in a few cases, at the very beginning they were seen on the opposite side. In my preparations I was able to find all stages of the conjugation of the polar nuclei, until their complete union to form the nucleus of the embryo-sac, or definitive nucleus (figs. 3, 4, 5, 6). My observations agree in general with those of Guignard on the conjugation of the polar nuclei in Lilium Martagon.

[6] The nature and distribution of attraction-spheres and centrosomes in vegetable cells. Bot. Gaz., **19**: 445–459. 1894.

Of the two conjugating nuclei, the one from the upper end of the sac is nearly always the larger. When the two nuclei approach each other, the centrospheres join two and two, and the two couples then separate so as to permit the two nuclei to come in contact (fig. 3). While the two nuclei are fusing, the attraction-spheres gradually unite and in them can be distinguished the two controsomes lying very close together (figs. 4, 5, 6). When the two nuclei have nearly fused, the centrosomes are in contact and are also uniting (fig. 6). The fusion of the two nuclei takes place by a gradual interchange of their contents. The chromatin does not seem to unite as definite chromosomes, but there appears to be a gradual intermingling of the individual particles from which a new chromatin network is built up. The nucleoli of the two nuclei appear distinct even to an advanced stage of the conjugation, but later there appears but one, in most cases, in the definitive nucleus, showing that there has been a union of the material of the two nucleoli, or the formation of a new one from nucleolar matter derived from the old ones (fig. 7). But the intermediate processes were not observed.

The endosperm is not very abundant when the embryo is completely developed. It appears to be formed entirely from the definitive nucleus. The first division of this nucleus generally precedes the first division of the oospore (fig. 19). These nuclei continue to divide and spread out through the embryo-sac as it increases in size. In one case I observed four endosperm cells at the time when the first division of the oospore was in the close daughter-skein stage (fig. 8).

Phenomena of fertilization.

The young pollen grain has two nuclei, a large one, which never stains very dark with anilin-safranin, and a smaller one which takes an intense dark red stain (fig. 9). Subsequently this small nucleus divides again (figs. 10, 11, 12), thus leaving the mature grain with one large nucleus and two small ones. These small nuclei always stain a very intensive red with anilin-safranin. When the pollen grain falls on the stigma and germinates, its tube passes through the style and thence down through the tissue on the inner side of the ovary. At the base of this the tissue is so arranged that the tube readily finds its way toward the base of the funiculus, where it comes into the free cavity of the ovary. Here it is

generally much contorted before reaching the micropyle, through the middle of which it finally passes to the top of the embryo-sac. Just before the entrance of the pollen tube into the micropyle, the two synergidæ, as stated before, lie at the summit of the embryo-sac, with the oosphere suspended below. The tube in passing through the micropyle is considerably constricted, but when it reaches the embryo-sac it increases appreciably in diameter (fig. 14). On reaching the apex of the sac, the pollen-tube does not grow directly toward the oosphere, but always passes down on one side near the wall of the embryo-sac encountering the nucleus of one of the synergidæ on its passage, which disappears at this time. The tube passes by the nucleus and seems to be nourished by its contents. At a certain stage the outline of the nucleus and its nucleolus can still be distinguished, but it takes little or no stain (fig. 15).

The nucleus of the other synergida persists for a long time, at least until the proembryo is composed of several cells. The pollen-tube after entering the embryo-sac takes a very dark-red stain and in it can be distinguished two small nuclei, which stain exactly like those in the mature pollen-grain. The deep red staining of the tube is perhaps due to the nourishment which it receives from the disintegrating synergida. The upper nucleus of the pollen-tube always appears spindle-shaped or much elongated (figs. 7, 13, 14, 16). The lower one is more spherical and is preceded by two centrospheres (figs. 7, 13, 16). These centrospheres are usually very distinct, because of the clear color of the attraction-spheres in contrast to the dark red stain of the surrounding material. The upper nucleus remains in the tube after fertilization is accomplished (figs. 18, 19). The pollen-tube usually curves toward the oosphere before the sperm nucleus leaves it (fig. 17).

In the meantime changes are taking place in the oosphere. The centrospheres lie on the side toward the sperm nucleus (figs. 13, 16, 17). They also appear to travel toward the sperm nucleus, since at this stage they are farther from the nucleus than usually (figs. 13, 17). The nucleus of the oosphere is no longer symmetrical in outline as in the earlier stages, but is drawn out on the side toward its centrospheres into a considerable bulge (figs. 13, 16, 17). Thus it will be seen that all the preliminary stages in the approach of the

two sexual nuclei indicate a conjugation of the centrospheres, or what has been called a "quadrille of the centres."

I made hundreds of sections in the vain attempt to follow out the stages of conjugation of the male and female pronuclei, but my material proved to be very unfavorable. I succeeded in finding but one instance of actual conjugation (fig. 18). In this section the sperm nucleus had left the pollen-tube and was in contact with the egg nucleus. No centrospheres were seen. They were very likely lying just above and beneath the line of contact and were thus invisible. However, the positions of the four centrospheres immediately before conjugation indicate the same kind of action as was observed for the two polar nuclei.

Recently, several American zoologists have attempted to investigate the phenomena connected with the conjugation of the male and female pronuclei. Wheeler,[7] in studying the fertilized egg of *Mysostoma glabrum*, concludes that the archoplasm and centrosomes of the segmentation nucleus come entirely from the female pronucleus. He found no trace of such structures in the male pronucleus. Hence he thinks there can be no "quadrille of the centers." Wilson and Mathews[8] in their investigation on the echinoderm egg also tend to disprove the "quadrille of the centers."

Mead[9] studied maturation and fecundation in Chaetopterus pergamentaceus. He traces the archoplasm and centrosomes of the segmentation nucleus from the male pronucleus, and states that these structures disappear from the female pronucleus after the extrusion of the second polar body. Thus he can also find no "quadrille of the centers."

It appears that there is not so much contradiction in the observations as in the conclusions drawn. And it should be borne in mind that mere negative results of observation prove or disprove nothing. As Strasburger has indicated in his "Neue Untersuchungen," in regard to the invisibility of the nucleus in the ripe pollen-grain of many dicotyledons when treated with certain nuclear stains, the invisibility of the nucleus in such cases must not be interpreted as indicating the absence of a nucleus, but much rather that the methods of

[7] The behavior of the centrosomes in the fertilized egg of *Mysostoma glabrum* Leuckart. Jour. Morph. **10:** 305. 1895.

[8] Maturation, fertilization, and polarity in the echinoderm egg. New light on the quadrille of the centers. Jour. Morph. **10:** 319. 1895.

[9] Some observations on maturation and fecundation in *Chaetopterus pergamentaceus* Cuvier. Jour. Morph. **10:** 313. 1895.

preparation and staining were deficient. And subsequent developments prove the wisdom of the caution. When we compare the size of an ordinary nucleus with a centrosphere it will be seen that the suggestion in the present case becomes one of great importance.

No division of nuclei was observed in the pollen-tube. The two small nuclei in the tip of the tube, after it has entered the embryo-sac, are about the same size and take the same stain as those in the pollen-grain. These are the two sperm nuclei which come from the generative nucleus. In this case the division of the generative nucleus occurs in the pollen-grain, while more commonly it does not take place until the tube is entering the embryo-sac, as shown by Guignard and Strasburger. Strasburger has found[10] that this early division of the generative nucleus occurs in many monocotyledons, and dicotyledons. Whether the two sperm nuclei are of the same nature or whether only one of them has the power of fertilizing the oosphere, I could not determine. The appearance of the two nuclei after entering the embryo-sac would indicate that only one was a true sperm nucleus. The fate of the vegetative nucleus was not discovered, but no trace of it was seen after the pollen-tube had entered the embryo-sac.

The early development of the embryo.

It was not my intention to study the development of the embryo, but while making observations to determine the length of time that the nucleus of the remaining synergida persisted, I found that the development of the proembryo, as presented in my sections, did not agree with the statements regarding Alisma in the text books.[11] After the union of the male and female nuclei, the resulting nucleus divides in a direction at right angles to the long axis of the embryo-sac (fig. 8). The upper cell with its nucleus immediately begins to enlarge, the nucleus taking a central position (fig. 20). The lower cell increases considerably in length, the lower end becoming somewhat rounded and swollen and containing the lower nucleus. This nucleus now divides again in the same direction as the preceding division, making three nuclei for

[10] Neue Untersuchungen, etc. 8.

[11] See Goebel's Outlines of Classification and Morphology, English edition, 399. 1887; and Sachs' Text-Book of Botany, second Engl. edition, 589. 1882.

the proembryo (fig. 21). At this stage the nucleus of the one synergida still survives but it shows signs of disintegration. It disappears after this stage and its contents very likely go to nourish the enlarging nucleus of the suspensor cell. The next division is again in the lowest of the three cells, in a transverse direction (fig. 22). This gives the first four cells of the proembryo. These divisions are absolutely certain, for they were traced out through stages in which the nuclei were in the close daughter-skein, which leaves no doubt as to the origin of the different nuclei in the series. The next division which occurs is in the lowest of the four cells. This now divides in a longitudinal direction (fig. 23). The development was traced no farther. But the course described above was confirmed by numerous examples. Thus the early development of the proembryo of Alisma either presents variations, or the descriptions given by Hanstein and Famintzin are incorrect. At a later stage, three suspensor cells could still be seen (fig. 24), but whether these were the same as those seen in fig. 23, or represented cells which originated by subsequent divisions, I did not determine.

Summary.

The results of the investigation may be summed up as follows:

1. The development of the embryo-sac of Alişma Plantago represents nothing unusual, the fully matured sac having the usual eight nuclei.

2. During the conjugation of the two polar nuclei, the four centrospheres conjugate by couples, resulting in the formation of two new ones for the definitive nucleus.

3. The endosperm is not abundant and comes entirely from the division of the definitive nucleus, the antipodal cells showing no division or fragmentation.

4. The division of the generative nucleus of the pollen occurs in the pollen grain.

5. Both of the sperm nuclei enter with the pollen tube into the embryo-sac, but only the lower one takes part in the act of fertilization, the other one remaining in the tube.

6. The nucleus of one of the synergidæ is entirely absorbed when in contact with the pollen tube. The other one is later also dissolved, its substance being used probably to nourish the large nucleus of the suspensor cell.

7. The centrospheres of the lower sperm nucleus precede it as it approaches the oosphere.

8. The nucleus of the oosphere becomes bulged out on the side nearest the sperm nucleus, and its centrospheres being situated immediately opposite this bulge, travel slightly toward the approaching male nucleus.

9. All the stages preliminary to the conjugation of the male and female nuclei are favorable to, and indicate a conjugation of their centrospheres, at the time of impregnation of the oosphere.

10. After the first division of the oospore, in the development of the proembryo, the three succeeding divisions take place each time in the outermost cell, the first three divisions being transverse to the long axis of the embryo-sac, the fourth one longitudinal.

Ann Arbor, Michigan.

Explanation of Plates IX and X.

Fig. 1. A young nucellus with macrospore and remains of the tapetal cell at the upper end.

Fig. 2. Mature embryo-sac with eight nuclei.

Fig. 3. Two polar nuclei just before conjugation, showing the centrospheres joining in couples.

Fig. 4. Conjugation of polar nuclei; the attraction-spheres have fused; the centrosomes lie close together in the united attraction-spheres.

Fig. 5. Conjugation of polar nuclei; the larger nucleus is from the upper end of the embryo-sac.

Fig. 6. Advanced stage of conjugation of polar nuclei; the two couples of centrosomes are fusing.

Fig. 7. Embryo-sac, showing one of the synergidæ, the oosphere, the definitive nucleus of the embryo-sac, the three antipodal nuclei, and the pollen-tube containing two nuclei. The lower male nucleus is preceded by two prominent centrospheres.

Fig. 8. Embryo-sac with oospore dividing, and with endosperm cells.

Fig. 9. Pollen-grain with a large and a small nucleus.

Fig. 10. Pollen-grain, showing the small nucleus in stage of division.

Fig. 11. Pollen-grain with the division of the generative nucleus farther advanced.

Fig. 12. Mature pollen-grain with one large and two small nuclei.

Fig. 13. Upper end of the embryo-sac, showing the appearance of the conjugating sperm-nucleus after leaving the pollen-tube. Below this sperm-nucleus is the oosphere, while at the apex of the sac is the remaining synergida, and at the left of the latter is the second sperm-nucleus of the pollen-tube.

Fig. 14. Outer end of the ovule, showing the pollen-tube passing through the micropyle and into the embryo-sac.

Fig. 15. Upper end of the embryo-sac, with the pollen-tube absorbing the contents of the nucleus of one of the synergidæ, the latter being but lightly shaded.

Fig. 16. Embryo-sac, showing the two centrospheres of the oosphere and those of the lower sperm-nucleus in their usual position at this stage.

Fig. 17. Upper end of the embryo-sac; the oosphere is bulged out on the side toward the pollen-tube; the centrospheres lie some distance above this protuberance.

Fig. 18. Conjugation of the nucleus from the pollen-tube with the oosphere. Above to the right is the other sperm-nucleus, and to the left the remaining synergida.

Fig. 19. Embryo-sac. The upper nucleus of the pollen-tube still persists, as does also one synergida; while the oospore is in the segmented-skein stage, and the definitive nucleus of the embryo-sac has nearly completed division.

Fig. 20. First two cells resulting from the division of the oospore. The nucleus from one of the synergidæ appears at one side of the upper cell.

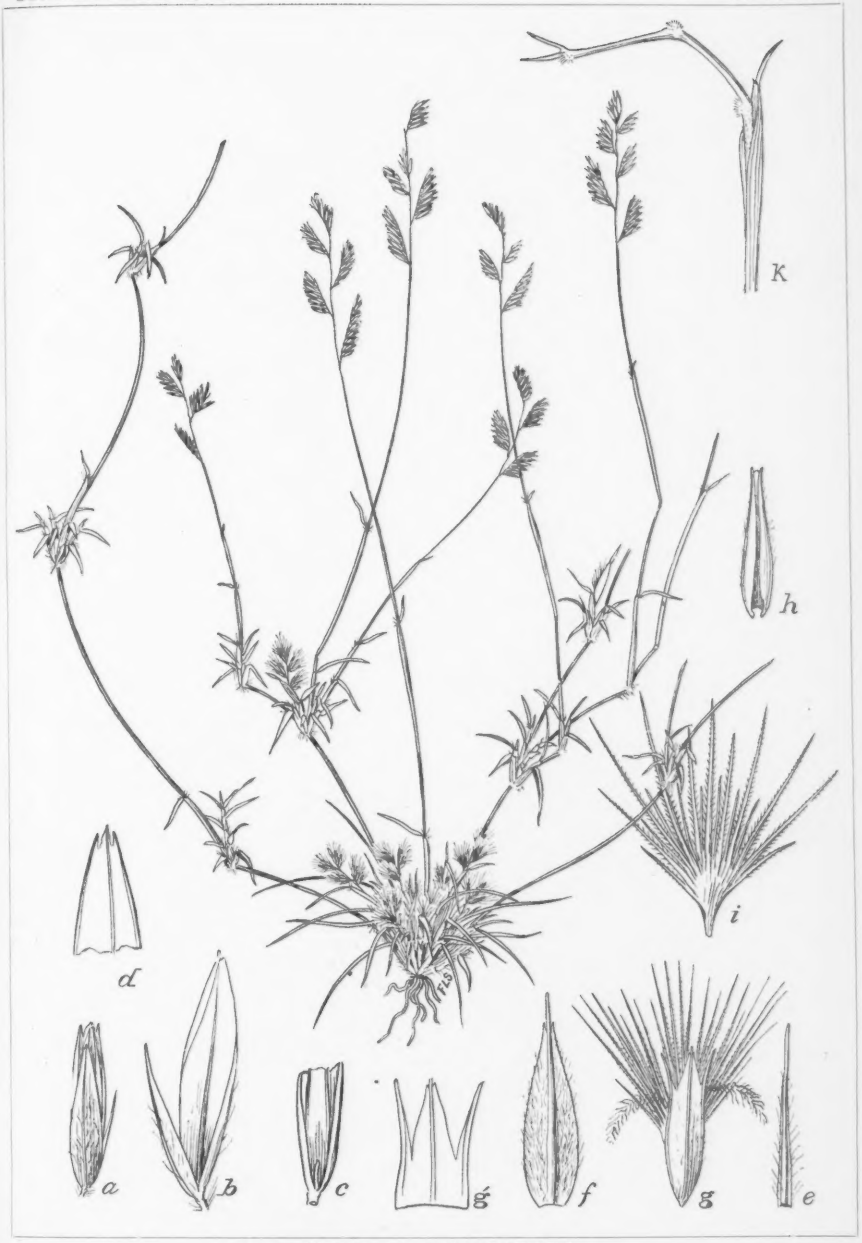
Fig. 21. Proembryo with three cells. The upper suspensor cell with its nucleus is becoming very much enlarged. In its upper end appears the nucleus of one of the synergidæ.

Fig. 22. Proembryo with four cells. Two endosperm nuclei appear free in the embryo-sac.

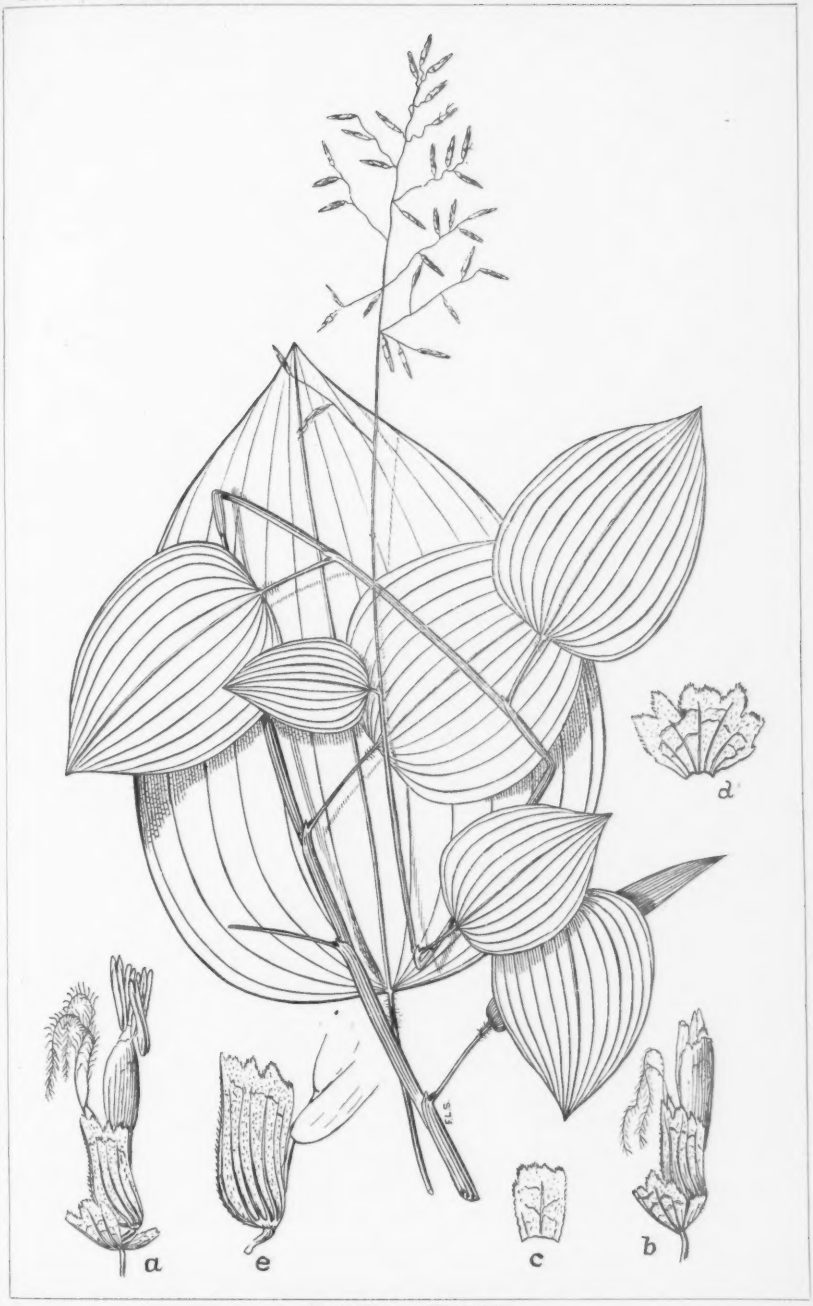
Fig. 23. Proembryo with five cells. The three nuclei in the embryo-sac are endosperm.

Fig. 24. More advanced stage of the embryo, showing three suspensor cells.

SCRIBNER on AVENA.



SCRIBNER on PRINGLEOCHLOA.



SCRIBNER on ZEUGITES.

New North American Grasses.

F. LAMSON-SCRIBNER.

WITH PLATES XI–XIII.

Avena Mortoniana, sp. nov.—Gramen humile, caespitosum alpinum, perenne, 4–6-pollicare, paniculis paucifloris, 1–2-pollicaribus. Culmi erecti, rigidi, striati, glabri; vaginæ glabræ vel minute pubescentes superne; ligula plus minus semi-linealis, decurrens, lamina 4–6-pollicaris, lineam lata vel angustior, rigida, convoluta siccitate, subtus glabra, supra pubescens, minute scabra marginibus. Radii paniculæ singuli vel geminati, breves, erecti, 1–3 spiculas ferentes. Spiculæ plus minus 5 lineas longæ, biflorae, flos secundus densissime hirsuto articulo rachillæ elevatus, plerumque imperfectus vel rudimentum, interdum omnino nullus, pedicella sola manente; glumæ vacuæ flosculos excedentes, lanceolato-acutæ, prima uninervis, secunda quam prima paulo longior, trinervis; gluma florens floris perfecti 4–4½ lineas longa, glabra vel superne scabriuscula, firmomembranacea praeter per margines scarios apicemque, dorso aristata prope medium; arista inferne contorta, geniculata, scabra, 7–8 lineas longa; callus basi glumæ florentis densissime pilosus, pilis sublinealibus; palea glumam aequans fere, lanceolata, carenis minute subdenseque ciliatis in dimidio superiore.—*Tab. XI.*

Allied to *Avena Hookeri* Scribn., from which it is distinguished by its smaller habit, shorter panicle, smaller and fewer flowered spikelets, longer bearded callus, and more densely plumose prolongation of the rachilla.

Mountain summits near Silver Plume, Colo., altitude 13,000–14,000ft. August. Nos. 697 *C. L. Shear* and 2,439 *P. A. Rydberg*, 1895. Rydberg's specimens were collected on Gray's Peak. Named for Hon. J. Sterling Morton, secretary of agriculture, in recognition of his interest in the promotion of the science of agrostology.

Danthonia Parryi, sp. nov.—Gramen erectum, subgracile, perenne, 1–2-pedale, vaginis marcidis culmos basi amplectantibus. Vaginæ glabræ praeter fauces, internodis breviores sed plerumque laminas superantes; ligula annulus breve ciliatus; laminæ 2–4 pollices longæ summæ plerumque breviores,

innovationum hanc longitudinem excedentes, circa sesquilineam latæ, sensim in apices longiusculos filiformesque attenuatæ, minute scabræ per margines et nervo supra. Panicula simplex, 3–7 spiculis, axe commune pedicellisque subcompressis, scabrisque; spiculæ plus minus decem lineas longæ, 5–7-floræ; glumæ vacuæ membranaceæ ovato-lanceolatæ, acutæ, trinerves aut basi 5–7-nerves, subaequales, flosculos paullo superante; glumæ florentes quam vacuæ paullo firmiores, plus minus 7 lineas longæ, ovatæ, plerumque 11-nerves basi, trinerves superne, dorso marginibusque longiuscule sericeo-pilosæ, apice dentibus aristato-acutis. Callus longiusculus, lateribus dense barbatis. Arista 6–7 lineas longa, robusta, inferiore parte plana, laxe contorta, pallide-straminea, superiore attenuata, plus minus scabra. Palea plus minus 5 lineas longa late-ovata, brevissime ciliata per margines et apice acute bidentata.

This species has been referred both to *Danthonia sericea* Nutt. and *Danthonia intermedia* Vasey. It is distinguished from the former by the glabrous sheaths and leaves and more simple and strict inflorescence, fewer and larger spikelets, broader less acuminate and glabrous empty glumes, flowering glumes hairy upon the back as well as the margin, and stouter awns. It differs from *Danthonia intermedia*, to which it is more nearly allied, by its more robust growth, usually fewer and much larger spikelets, comparatively narrower empty glumes and more copiously hairy flowering glumes (in *Danthonia intermedia* the flowering glumes are hairy only along the margins); the teeth of the flowering glumes are also much longer, and the awn about twice as long.

My attention was first called to this species by some specimens collected by Dr. Parry in Colorado. It equals no. 2,397 *Rydberg*, collected in the valley about three miles north of Georgetown, Colo., August 19, 1895. It was distributed by E. Hall in 1862. No. 1,170–1 *J. Wolfe*, collected at Twin Lakes, Colo., appears to be the same thing, with much elongated leaves, and rather more numerously flowered panicles. The leaves in this form exceed a foot in length, and it may be designated as var. *longifolia*.

Zeugites smilacifolia, sp. nov.—Planta perennis; culmi validiusculi, simplices, 3–5-pedales, glabri, fusci, nitidi; vaginæ purpurescentes minutissime scabræ, pilis paucis papillatis superne juxta margines. Folia glabra, petiolata, inferiora

remota, superiora approximata, usque ad 4 pollices longa, $2\frac{3}{4}$ pollices lata, basi subcordata, apice acuta, nervis primariis 11–13, arcuatis, venulis transversis inter se anastomosantibus utrimque distinctis; petioli graciles $\frac{1}{2}$–$1\frac{1}{4}$ pollices longi, basi pulvinis distinctis, apice pubescentes. Panicula 4 pollices longa, laxe patens, paucispiculata, ramis gracilibus inaequalibus plerumque geminatis. Spiculæ virides 3–$3\frac{1}{2}$ lineas longæ, 2–3-floræ; glumæ vacuæ inaequales, prima paulo linea longior, latior quam longa, inaequaliter dentata, saepe 7-nervis, venulis transversis connectis, marginibus minute ciliolata; gluma secunda oblonga, truncata, quam prima brevior multoque angustior, 1–3-nervis, venulis transversis, apice lata minute ciliolata, flosculus femininus articulo racheos $\frac{1}{2}$ lineam longo elevatus. Gluma florens feminina, 2 lineis paulo brevior, dorsi scabra, basi gibbosa, apice late truncata inaequaliterque dentata, marginibus minute ciliolata, 9–11-nervis venulis connectis. Palea angustissima, glumam aequans, carinis apiceque dense pubescentibus. Gluma florens mascula, oblonga, dorso scabra, apice lata rotundata, 5–7-nervis, angusta palea paulo brevior.—*Tab. XII.*

Faucibus, prope Cuernavaca, Morelos civitate. 20 Nov. (Pringle n. 5,961.)

The leaves of this well-marked species resemble in outline and venation those of some species of smilax. The false petioles consist of two parts, one an evident continuation of the leaf-sheath which occupies the greater part, and an upper pubescent part, which is manifestly a petiole-like downward extension of the blade. From this latter part arise the eleven to thirteen primary nerves, like so many rays. The limits of these two parts of this false petiole are quite sharply defined, but there does not appear to be any point of articulation between them. The pulvini at the base of the pseudo-petioles cause the leaves to diverge.

The material in the National Herbarium does not permit a comparison with all the published species, and unfortunately the descriptions of some of the species are too brief to be of much value as means of identification. I present below a description of the genus *Zeugites*, and, as far as I am able from the specimens and publications, a brief characterization of the species. *Zeugites Munroana* Hemsl., from Guatemala, Hemsley himself refers to *Z. Galeottiana*. In the Index Kewensis *Zeugites Americana* Rupr., not Willd., is referred to *Z.*

Mexicana, and *Z. Jamaicensis* Rausch is referred to *Z. Americana* Willd. I think it very likely that *Z. colorata* Griseb., and *Z. Hartwegi* Fourn., are not distinct from *Z. Americana* Willd.

ZEUGITES Schreb.—Spiculæ 3–8-floræ, paniculatæ, flore inferiore femineo superioribus masculis. Glumæ 2 inferiores vacuæ latissimæ, apice rotundatæ vel truncatæ, saepe subdentatæ, inter nervos saepius transversim venulosæ; tertia florem fertilem fovens vacuis similis nisi paullo major; superiores 2–7-flores masculos foventes angustiores, venulis transversis raris; palea angusta, hyalina, 2 carinata.—Gramina nunc debilia basi decumbentia ramosa, nunc elatiora valida, foliis planis petiolatis vel sessilibus, ovatis vel ovato lanceolatis inter venas transverse venulosis. Panicula terminalis, nunc laxa effusa, spiculis paucis nutantibus, nunc dense floribunda. (Char. ex Benth. et Hook. Gen. Pl. **3:** 1191.)

Spiculæ 6–10-floræ.

Z. latifolia Hemsl. Biol. Centr. Am., Bot. **3:** 577.
Krombholzia latifolia Fourn. Mex. Pl. Enum., Gram. 122. (Leibm. n. 541).

Planta robusta, culmo valido, foliis subsessilibus, late cordatis, lanceolatis, 4-pollicaribus. Panicula pedalis fere, spiculis laevibus 5-lin. longis, 8–10-floris.

Z. Galeottiana Hemsl. l. c.
Krombholzia Mexicana Rupr. in Bull. Acad. Roy. Brux 6:—[n. 8.] (Galeotti n. 5,751).

Planta pusilla, foliis parvis, cordato ovatis, breviter petiolatis; panicula depauperata 3–4-spiculata; spiculæ 7-floræ, glumis vacuis parvis inequalibus, integris.

Spiculæ 2–4-floræ.

Z. Americana Willd. Sp. Pl. **4:** 204.
Apluda Zeugites L.

Culmi 1–2-pedales. Folia ovata, acuta 1–2 pollices longa, 6–10 lineas lata; petiolis glabris. Paniculæ rami inferiori ternati. Gluma florens femina aristata; arista erecta, glumæ dimidiam longitudine vel paulo brevior. Spiculæ 3-floræ, floribus masculis distantibus.

Z. Hartwegi Fourn. l. c. 121.
Despretzia Mexicana Benth. non Kth. (Hartweg no. 569).

Planta gracilis ramosa, pedalis vel ultra. Panicula pauci-

spiculata; spiculis 3–4-floris glumis vacuis dentatis, pubescenti-ciliatis, gluma florens femina apice mucronata. Vide supra.

Z. Mexicana Trin. ex Steud. Nom. **2**: 798. [ed. 2].
Despretzia Mexicana Kunth Revis. Gram. **2**: 485. *pl. 157.*
Culmi graciles caespitosi, basi ramosi, repentes, geniculato-erecti. Folia ovata acuta, basi rotundata, petiolata. Paniculæ ramosæ depauperatæ patentissimæ. Spiculæ 3–4-floræ longe pedicellatæ cernuæ, lanceolatæ, virides. Glumæ vacuæ glabræ, longitudine subequales; gluma florens femina mutica.

Z. colorata Griseb. Flor. Br. W. Ind. 536 in obs.
Folia oblongo-lanceolata; petioli apice pubescentes; gluma florens femina breviter mucronata. Vide supra.

Z. smilacifolia Scribn.
Planta validiuscula. Culmi 3–4-pedales, simplices. Folia petiolata, usque ad 4 pollices longa, $2\frac{3}{4}$ pollices lata, petiolis apice pubescentibus. Panicula laxa, sub 4-poll. longa, paucis spiculis. Glumæ vacuæ inequales, dentatæ, scabræ, marginibus ciliatæ. Spiculæ 3-floræ, 2–3 lin. longæ. Gluma florens femina latissima, mutica, dorso scabra, marginibus ciliata.

Pringleochloa, gen. nov. Tribus CHLORIDEÆ Benth. et Hook. Gen. Plant. **3**: 1087.—Spiculæ monoicæ, dense biseriatim imbricatæ per latus racheos continuæ, complanatæ, ultra summam spiculam excurrentis. Spiculæ masculæ femininis dissimiles. Spiculæ masculæ unifloræ, rhachilla ultra florem in stipitem minimum producta; glumæ vacuæ 2, valde inaequales, prima quam secunda multo minor, uninerves, muticæ; gluma florens 3-nervis, apice breveter tridentata, glabra; palea glumam aequans 2-nervis; stamina 3, pistillus nullus; spiculæ femininæ unifloræ, glumis vacuis rudimentis multiaristatis 2–3 supra floram; glumæ vacuæ inferiores 2, valde inaequales, prima quam secunda brevior et multo angustior; gluma florens 3-nervis, aristis brevibus 3 inter dentes apicis; palea glumam aequans; stamina nulla, styli distincti, stigmata longe plumosa.

Gramen humile, perenne, stoloniferum, ramis gracilibus ascendentibus, foliisque brevibus subrigidis.

Dedicated to Mr. C. G. Pringle, who for many years has

been collecting plants in our southwestern states and territories and in Mexico, and who has, perhaps, done more towards increasing our knowledge of the plants of these regions than any other collector.

Pringleochloa stolonifera, nom. nov.—Culmi stoloniferi ramis floriferis erectis vel ascendentibus 2–6 pollices altis. Spicæ masculæ 3–6, approximatæ, 8–20 spiculatæ ex vagina summa longe exsertæ, infima circa ½ pollices longa, superioribus deinceps sensim brevioribus, spiculæ dense imbricatæ, subsessiles, basi pubescentes, circa 2 lineas longæ; gluma prima angustissime lanceolata, apice subulata, circa 1½ lineas longa, secunda multo latior, glumam florentem subaequans. Spicæ femininæ 3–4 per axes communes breves confertæ, 4–6-spiculatæ, infima saltem in vagina summa inclusa; spiculæ cum aristis florum rudimentorum 3½ lineas longæ; gluma prima setiformis, prope 1½ lineas longa, parce et breviter pilosa; secunda lanceolata, quam prima longior, dorso sericeo-villosa, apice minute bifida, nervo medio valido in mucronem brevem aristiformem inter dentes excurrente, flosculi rudimenta plerumque 2–3, ad glumas vacuas inaequaliter aristatas reducti, stipitibus brevibus vel articulis rachillæ elevati.—*Tab. XIII.*

Thinly carpeting, here and there, the calcareous plains around Tehuacan in eastern Puebla, a region rendered arid by its situation on the west side of the mountain chain connecting Mt. Orizaba with the mountains of Oaxaca. (Pringle, no. 6,280.)

This singular grass is closely related to Bouteloua, but possesses a remarkably composite line of characters. It is monoecious like Buchloe, and, like that grass, has the staminate spikes raised on the taller upright branches of the culm and long-exserted, while the female spikes are almost concealed among the leaves at the base of the tufts, and are at least partially enclosed within the inflated leafsheaths. The appearance of the staminate inflorescence very closely resembles that of *Dinebra chondrosioides*, as figured in HBK. Nov. Gen. Plant. **1:** *pl. 53*. The spikelets, however, are strictly 1-flowered and staminate, and the prolongation of the rachilla behind the palea is a short bristle, and does not extend into a 3-awned rudiment. The pistillate spikelets agree in many respects with those of *Eutriana multiseta* Nees; they are very densely crowded on the short partial rachis, and appear as

flabelliform clusters, but the awns of the flowering glume are much shorter, as are also the more numerous awns of the rudimentary florets above. These multi-awned glumes also suggest a relationship with Cottea and Pappophorum.

I have very little doubt of the identity of the species here described with *Atheropogon stolonifer* Fourn., the characters of which, as given by Fournier (Mex. Pl. Enum., Gram. 140), would apply to specimens bearing only female spikes. He describes the spikelets as hermaphrodite, but he may have too hastily assumed this, and overlooked their strictly unisexual character. Fournier's specimens, (Liebman no. 588) were collected in the same region, a fact which renders the identity still more probable.

Division of Agrostology,
U. S. Department of Agriculture,
Washington, D. C.

EXPLANATION OF PLATES XI–XIII.

Plate XI. Avena Mortoniana Scribner.
Plate XII. Zeugites smilacifolia Scribner.
Plate XIII. Pringleochloa stolonifera Scribner.

Fig. *a*. Staminate spikelet, showing the back of the second glume, etc. Fig. *b*. Empty glumes of the staminate spikelet, more highly magnified. Fig. *c*. Lower part of the staminate floret, showing the short continuation of the rachilla behind the palea. Fig. *d*. Apex of the flowering glume of the staminate spikelet. Fig. *e*. First glume of the pistillate spikelet. Fig. *f*. Second glume of the same. Fig. *g*. Pistillate spikelet, dorsal view, empty glumes removed. Fig. *h*. Palea of the female floret. Fig. *i*. Fourth glume of the pistillate spikelet. The glumes above these have successively fewer arms. Fig. *k*. Rachis, to which were attached three female spikes.

Some aqueous media for preserving algae for class material.

W. A. SETCHELL AND W. J. V. OSTERHOUT.

There are ordinarily two difficulties in the way of introducing a careful study of the various marine and fresh water algæ into a course in cryptogamic botany. The first of these is the obtaining of the material, and the second is preserving the material which may be obtained in such fashion that it can be placed before the student in a condition to be readily examined and studied with nearly as satisfactory results as those afforded by the fresh material of the same forms.

The first difficulty can be overcome more or less readily. Fresh water species are more or less abundant in our ponds, brooks and rivers, and the increasing facility of access to the sea brings the marine forms within the reach of many. Especially do the facilities offered by the marine laboratories, such as those at Cold Spring Harbor, N. Y., at Woods Hole, Mass., and at Pacific Grove, Calif., afford an opportunity for the teacher of botany not only to become acquainted with the algal forms and their use in the class room, but also to obtain and preserve a good supply of desirable species in the very best condition possible. Under the auspices of the Marine Biological Laboratory at Woods Hole, a Department of Laboratory Supply has been in successful operation for several years, and from it all necessary botanical material may be very satisfactorily and economically obtained.

The old method of preserving in strong alcohol shrivelled the specimens to such an extent that the use of strong swelling reagents (alkalies or acids) was necessary to show anything like the proper degree of detail of structure, and while these methods were good for the ordinary tougher species, and when applied by students of some experience, yet they were very unsatisfactory when applied to the more delicate forms or when used by the more inexperienced manipulators.

The use of the weaker alcohol, 50–70 per cent. according to the particular specimen to be preserved, was better, yet proved decidedly unsatisfactory for the more delicate forms.

The ordinary English method of fixing in a saturated solu-

tion of picric acid and preserving in strong alcohol is a very good one, especially for specimens to be imbedded in paraffin or for special work in connection with particular problems. Better still is fixing in some special solution such as a saturated solution of picric acid, 0.5–1 per cent. chromic acid, Perenyi's fluid, Hermann's mixture, etc., and transferring through the ordinary grades of alcohol, or by dialysis, up to 70 per cent. strength and preserving in that.

Such material is in excellent condition for imbedding in paraffin or celloidin, but for the ordinary class work, for manipulation by the student himself, the specimens must generally be transferred again to water.

But the preparation by these methods of material for a large class is often a considerable task. The more delicate forms too are seldom in a thoroughly satisfactory condition.

It has been found to faciliate the class-work on all the cryptogams very much to use freezing methods in the preparation of sections for the class, and either to have the sections cut by an assistant or by different members of the class at different times. A description of a convenient freezing device and methods of imbedding in aqueous media will be published by one of us in the next number of this journal.

Freezing methods and the preservation of natural form and size of the different parts with as little change as possible have rendered it very desirable that aqueous media be employed if possible for preserving fluids.

A number of fluids have been subject to experiment by the writers for about three years, particularly upon the abundant materials of all groups of algæ obtained at the Marine Biological Laboratory at Woods Hole, Mass. It is thought by the writers that these notes of their experience, while containing nothing especially new, may serve as useful hints to those who have before them the problem of providing and preserving cryptogams for laboratory purposes.

Chrome alum.

This substance was used by Guignard[1] for fixing various Laminariaceæ for the purpose of investigating the structure and development of the mucilage ducts. Later it has been tested at the Biological Station at Helgoland by Lotsy[2] upon

[1] Ann. Sci. Nat., Bot. VII. **15:** 1–46. 1892.
[2] Bot. Centralblatt **60:** 15–16. 1894.

the red algæ particularly as to the preservation of the cell-structure.

The writers have used one per cent. chrome alum in either distilled water or sea water carefully filtered through sand, according to the different habitat, for about four years. The algæ, carefully selected and washed free from dirt and debris, have been placed in it at once and preserved in it until needed for examination. The cell structure is well preserved in all cases. Very little washing is needed afterwards to allow staining by any of the ordinary staining reagents. Gelatinous intercellular substances, whether soft or more cartilaginous, are rendered firm but not especially opaque by treatment with it. Cyanophyceæ, Chlorophyceæ, and Rhodophyceæ do very well indeed. Phaeophyceæ, almost without exception, are rendered brittle in a short time, but while this renders them troublesome to manage, yet specimens prepared in this way and soaked out in water are excellent for study by crushing methods. It is the intercellular substance that is rendered brittle and such forms as species of Leathesia, Mesogloia, Laminaria, etc., when crushed, spread out and show the cell structure and cell arrangement in a very satisfactory fashion. The color is not retained perfectly, but is ordinarily retained more than by any other of the media we have tried.

The Chlorophyceæ lose all of their green, or nearly all. The Cyanophyceæ and Rhodophyceæ often retain considerable (especially if kept away from the light), generally at least enough to assist materially in the examination of the chromatophores, while the Phaeophyceæ lose very little of their intensity. Specimens preserved in chrome alum must be kept in glass-stoppered jars, carefully closed, as the solution is liable to become invaded by various molds. A little finely divided camphor-gum at the top will prevent this, as will also a small quantity of formalin. Chrome alum solution has a certain corrosive action upon metals, so that metal tops to the preserving jars should be avoided, and specimens to be sectioned free-hand or with the freezing microtome methods, should have at least the greater part of the alum removed by washing.

One per cent. chrome alum is also an excellent preserving fluid for use with fungi of the various groups, for the mosses, for ferns and for flowering plants, better in all cases than the strong alcohol commonly used, but probably not superior to

the various percentages of formalin, except in the case of gelatinous forms. Spirogyra cells keep well in 1 per cent. chrome alum, the chromatophores, pyrenoids, nuclei and protoplasmic sac and threads showing very well indeed. Specimens kept in a cork-stoppered bottle in chrome alum showed a very distinct dark steel-blue stain affecting the nucleolus most, the nucleus and the chromatophores, and this remained after washing in water, dehydrating, and mounting in Canada balsam.

With chrome alum, as well as all other preserving media, a fairly large proportion of fluid should be used.

Formalin.

Formalin, formalose, or 40 per cent. formaldehyde, according to the trade name, has in the last two years become very popular with both zoologists and botanists. It is not necessary for us to go into the literature, but we have found that the 1–2 per cent. solution of the formalin (1–2^{cc} formalin in 99–98^{cc} distilled water or sea water) makes a solution sufficiently powerful to kill, fix, and preserve any ordinary vegetable tissue. While the color fades more rapidly than with chrome alum, the cell contents are preserved equally well. For Phæophyceæ, a 2 per cent. formalin solution is the very best fluid which we have tried. Cyanophyceæ preserve their structure but not the gelatinous matrix so well, since this is liable to shrink under the influence of formalin. Delicate Rhodophyceæ, such as Griffithsia, Callithamnion, Dasya, etc., keep their full form better than in any other fluid. Chlorophyceæ do equally well. Formalin solutions containing organic materials become acid after a short time and this may tend to alter the cell-contents or the intercellular substance slightly, but in preparations kept for nearly two years this is not sufficiently marked to be especially noticeable. Formalin in the same percentages works excellently for fungi and the higher plants. Toadstools are preserved in their natural shapes and in more or less of their natural colors according to the species.

Camphor water.

Camphor-gum is sparingly soluble in water, but the solution is very prejudicial to the life of microorganisms. Camphorated water is very useful when considerable collections have been made and cannot be examined for several hours.

In such cases small pieces of camphor-gum strewn in the water help to keep the algæ from putrefying until they can be studied or properly sorted and preserved. Formalin is useful also for this purpose, but the acidity produced changes the color quicker than is the case in camphorated water. For preserving Cyanophyceæ, camphor water keeps the cell structure well if present in large volume, proportional to the amount of material, but the coloring matter is soon dissolved. Chlorophyceæ, Phaeophyceæ, and Rhodophyceæ, if well sorted and cleaned, are well preserved in abundance of the fluid, even the finer details of cell structure being preserved perfectly. But perhaps the most important use of camphor water is to preserve specimens already fixed by other fluids. Specimens of the larger Rhodophyceæ, killed and fixed in concentrated aqueous solution of picric acid are preserved to especial advantage in camphor water; as one of us has experienced in special work upon *Rhabdonia tenera* Ag.

Summary of results.

Cyanophyceæ are best prepared with a solution containing 1 per cent. chrome alum and 1 per cent. formalin. This solution renders the gelatinous sheath and matrices firm, keeps the cell contents in a very natural condition, and retains in most cases the colors in their ordinary tints. 1–2 per cent. formalin solution preserves the cell contents very well indeed, but does not keep the color well, or the softer gelatinous sheaths and matrices. Camphor water is not very favorable for many blue-greens. Many species must needs be preserved in mass, and are associated with many bacteria and the camphor solution is hardly strong enough to wrestle successfully with the latter.

Chlorophyceæ are very satisfactorily preserved in any of these media. Chrome alum is to be preferred in most cases, but some species are rendered very brittle as, *e. g.*, membranaceous forms like Ulva Lactena. Such forms are of course better if placed in simple formalin solution.

Phaeophyceæ do well when placed immediately in 1 per cent. formalin in sea water. The larger forms are better fixed in 1 per cent. chrome alum for a few hours (3–6) and then preserved in 2 per cent. formalin solution or camphor water. But specimens for crushing may be allowed to remain indefinitely in the chrome alum solution.

Rhodophyceæ. The coarser forms may be put into any one of the three solutions and be in very excellent condition; chrome alum preserves more color than formalin or camphor water. For the finer study, specimens are best left in a concentrated solution of picric acid in sea water for twenty-four hours, then washed, preferably in sea water, for about twenty-four hours more, and preserved in camphorated sea water. Such genera as Nemalion, Champia, Rhabdonia, Cystoclonium, etc., respond best to this treatment. Delicate species need very careful consideration. Griffithsia Bornetiana is a most delicate species and, preserved in almost any way, collects itself together into a shapeless mass; the cells lose their shape, and it becomes a very uninviting object for study. But placed in 2 per cent. formalin in sea water with plenty of fluid so as not to be crushed, the cells keep their shape and the whole plant presents a life-like appearance as far as form goes. The color of course departs. The same thing is true of various species of Callithamnion, such as C. Baileyi, C. Borreri, C. seirospermum, etc. Dasya elegans has a way of dropping its hairs on being preserved, and the more delicate species of Polysiphonia break up into short pieces, but either formalin or chrome alum will prevent this if the specimens are fairly fresh when put into the preserving solution.

Berkeley, Cal., and *Providence, R. I.*

The purposes of ethno-botany.[1]

J. W. HARSHBERGER.

To the World's Fair in 1893 was brought a unique collection of objects obtained through the liberality of Mr. Hazzard by the Wetherill brothers in the Mancos cañon, Colorado. Never before in the history of American archæology had such a complete series of objects been brought together for study and comparison. The University of Pennsylvania was fortunate in securing through the efforts of Mr. Culin the loan of the entire collection, which stands unrivalled in showing a large series of interesting things; plant products in the form of food, dress, and household utensils being very largely represented. It is to the description of the plants and plant products that this article is directed.

Before describing, however, the objects which have been manufactured from plants, it is expedient to make a few preliminary observations on the importance of ethno-botany in general.

1. The study of ethno-botany aids in elucidating the cultural position of the tribes who used the plants for food, shelter or clothing. The well-known classification of men into savage, pastoral, agricultural and civilized will roughly serve our purpose. The term pastoral could hardly be applied to the tribes of North America. They were a roving people, traveling from place to place in search of game and settling only long enough to plant a little corn, beans and pumpkins to break the monotony of a too strict animal diet. Where they did not pursue agriculture, they subsisted on the seeds of wild grasses and herbs. The cliff dwelling peoples, probably driven to the mountain fastnesses, had practically left the hunter stage and had begun to enter the agricultural stage.

A people may be said to have left the pastoral and entered upon the agricultural stage, when chief dependence is placed upon the returns of the soil under cultivation. With the entrance upon this condition, new implements were devised, new methods of field labor introduced. An examination of

[1] A lecture delivered before the University Archæological Association, December 4, 1895.

the objects in the Hazzard collection clearly shows that they accomplished much by the use of very simple implements. The corn was planted by a pointed stick and hoed by a stick broadly flattened at one end. An examination of other manufactured articles of vegetal origin shows that these people were extremely provident; nothing was allowed to go to waste. It was too difficult a thing to carry the objects from below up the face of the cliff to their dwellings above, and they therefore exercised great care in putting everything to use. If it no longer served one purpose, it was devoted to another. Mr. Cushing has shown that this care was due to certain superstitions which they held concerning the soul of objects, animate and inanimate. For example, when the hollowed out pumpkin no longer served the purpose of a jar it was broken into pieces and the charred fragments served as a scraping instrument. The worn out fibers of Yucca were also conserved and made useful.

This careful husbanding of their resources may be directly traceable to two causes; first, it was difficult to carry large and bulky articles from the level of the cañon to the rocky shelves above, for in many cases steps had to be cut in the perpendicular face of the rock, climbing being facilitated by wooden climbing crooks, which afterwards were used by their descendants, the Pueblos, ceremonially; second, they lived in an arid region, where the materials ready at hand for the various uses of domestic life were extremely limited, and where the vegetal food supply was limited by the water supply, which in many seasons was very small. The panniers and baskets, made of cane grass with carrying frame attached, were very serviceable in transporting seeds and fruits from the campestrine levels to the cliffs above. The ladder in the collection, the rounds of which are bound to the uprights by yucca fiber, fulfilled essentially the same purpose. An examination of the collection also shows that they had advanced to the use of a double lever of the second class, for we find them employing a pair of cedar forceps which Mr. Cushing says were used to pick cacti, too prickly to be gathered in the ordinary way. In fact a large number of the objects as manufactured from plants shows that they had made considerable progress in the arts, and were less dependent, therefore, on the uncertain supply of food afforded by following hunting or fishing. In other words, they were to a certain extent in-

dependent of their surroundings and could, by planting crops, which they afterwards harvested and stored in granaries, eke out an existence.

2. An ethno-botanical study throws light upon the past distribution of plants. I have at some length shown[2] that a study of the native uses of maize, etc., leads to the belief that Indian corn was a native of southern central Mexico and from there by trade and barter was carried to the farthest points in North and South America. Another example is found in tobacco which was universally distributed throughout the American continents. The distribution of tobacco, however, is complicated by there being two or three species, which were used in different parts of the western hemisphere. One species (*Nicotiana rustica*) was cultivated by the Indians in New Mexico and Arizona, as observed by Dr. Edw. Palmer. Another species (*Nicotiana quadrivalvis*) was cultivated by the Indians from Missouri to Oregon. One or two species are recorded as having been cultivated in California.[3] One quotation will show that it was cultivated widely. Hernandez de Oviedo in his "Historia general de las Indias" (1535) describes the use of the plant in Sto. Domingo.

"Eine Kalebasse füllten die Indianer mit einem Kräuterpulver, das sie Cohobba oder Guioja nannten. In die Kalebasse steckten sie einfache oder gabelförmige Rohren, so dass eine oder beide Oeffnungen in die Nasenlöcher passten; denn die Insulaner rauchten ihren Tabak durch die Nase."[4]

The use of cedar was considerable. Cedar was used to make cactus pickers; cedar bark was twisted into headbands, woven into mats, and used in the broken up form as tinder. We find its use also in the eastern states, for in a collection of objects in the university museum taken from the Ohio mounds is a piece of a well preserved log although buried for hundreds of years. A microscopic examination shows the several cell wall layers still intact and the woody elements excellently preserved. These examples, with numerous others that might be taken from European archeology, for instance the existence of a peculiar variety of barley in the lake dwellings of Switzerland, prove that the study of plants in this way

[2] Maize: A botanical and economic study. Contrib. Botan. Laboratory Univ. of Pa. **1**: 75.

[3] U. S. Dept. Agr. Rep. **1886**: 76.

[4] A. B. Reichenbach, Die Pflanzen im Dienste der Menschheit. I. Der Tabak 2.

is of importance as deciding upon the original home and past distribution.

3. An ethno-botanical study helps us to decide as to the ancient trade routes. I have shown that maize was introduced into the West Indies by the tribes which had emigrated from the South American continent; that South America derived the cereal from the tribes living adjacent to the Rio Grande and tributaries.

Considerable difficulty, however, is experienced in the study of a single isolated plant, for the trade routes may have been various, but when we introduce as evidence two or at least half a dozen plants, we can determine with greater accuracy the main trade routes.

There cannot be any doubt that such trade routes existed. My grandfather used to narrate stories of the Indians that passed his father's house in central Pennsylvania on their way to the salt licks of Virginia. I remember seeing the trail that led southward through his woodland, as used by Chief Hogan and his band of hunters.

The discovery by Dr. Amos Brown of catlinite in the Hazzard Collection, also shows that the Indians of the southwestern United States had intercourse with the tribes residing in what is now the state of Minnesota. Mr. Joly says with relation to European archaeology: "How far the commercial relations of the primitive people of Europe extended and what routes they followed is a question the solution of which, like that of so many others, is as yet merely guessed at. However the presence of amber from the Baltic, and of white Mediterranean coral in Switzerland, Italy and elsewhere, of carved flints in abundance in the Isle of Elba where this rock does not exist in the natural state, arrows made of the black obsidian of Sardinia, found in the same island and in that of Pianosa, the jade axes found at Pauillac in the department of Gers; those of augite of Auvergne found in Brittany; the green turquoise of Brittany discovered in several dolmens in the south of France; all of these articles of which the rough material is foreign to the country where they are found, prove that from the earliest ages more or less commercial relations existed among the most ancient inhabitants of Europe." The same principles apply to the discovery of plant products in various parts of the globe. Commerce very early carried yew wood from the Rhine country to the Baltic, where the tree

was and thence to the Esths and Wends where the yew was not found.

The first step in deciding upon the ancient trade routes is to ascertain (1) what plants were used by the cliff dwelling Indians, for example, of the Mancas cañon in Colorado, (2) to systematically tabulate the distant and local plants and (3) to discover, if possible the home of the non-indigenous plants. When all of these points are decided upon, we shall have sufficient data with which to map out the Indian trade routes.

There are several ways by which the plants as used by the cliff dwellers can be determined. (*a*) By a direct botanical determination of the species of plant used. This is possible in many cases when we have seeds, nuts, tubers, bulbs, and berries used as food; also by a botanical analysis of the pot herbs which may have the leaves and flowers preserved. An examination of the human excrement might disclose by means of the undigested voided seeds, the plants that were used as food. In dealing, however, with the raw materials of manufacture, it is often very difficult to determine from what vegetal source they were derived. (*b*) A microscopic examination of the plant product will reveal much; for example, if it be a piece of wood, its woody characters. We could determine by such an examination whether the stem was that of an angiosperm or that of a gymnosperm. In case the piece of wood shows a gymnospermic structure, it is quite possible by use of knowledge already gained to determine whether it be yew wood or that of the pine, the fir, the larch and the juniper. A microscopic examination of a dicotyledonous stem would also help us in identifying the wood.

We have a piece of wood before us which we cut in order to determine its microscopic appearance. A striking feature in such a section is the concentric circle of ducts in the early spring growth of wood; in the thick rings sometimes there are two or three rows of ducts, the third one being of smaller size than the others. "The first row forms in the spring as the leaves are opening." The largest duct is usually round and 0.13 of an inch in diameter; some are smaller and others flattened or elliptical. Except when first forming these ducts are never open, as usually stated, but are filled with delicate tyloses. Surrounding these ducts are small cells, which are termed tracheids, having minute thin places in their sides; the middle lamella of the cell, however, being not visibly per-

forated. Some cells containing starch are also intermingled with these tracheids. In an annual layer of vigorous growth large bundles or masses of hard, dense fibers are seen just out of the concentric circles of ducts, and when fully formed extend through the outer part of the layer. These fibers vary in diameter from .006 to .0075 of an inch. The medullary rays run through the bundles and at frequent intervals are intersected by cells running parallel to the axis of the tree, thus dividing a mass of hard fibers into small rectangles. Such a detailed description coincides with the structure of the white oak, and after applying further tests we can rest assured that the wood is from one of the most valuable of our forest trees.

If the study of the microscopic structure leads to no definite conclusion as to the nature of the wood, then we might have recourse to other methods. (1) The specific gravity of the specimen can be readily calculated whether the wood is heavier or lighter than water. A piece of wood tested in this way showed a sp. gr. of 0.4504. Upon comparing this figure with that of the tables in Sargent's voluminous work on the North American forest trees we find the number to correspond with that set down for chestnut wood. (2) An ash determination is also a means of discovering the species of tree from which the wood was taken. (3) The weight of the wood per cubic foot in pounds, and its fuel value are also means of deciding as to the kind of tree used.

We have now seven important facts concerning our piece of wood:

1. Its geographical habitat.
2. Its specific gravity.
3. Its microscopical structure.
4. Its fuel value.
5. Its resistance to transverse strain and compression.
6. Its weight in pounds per cubic foot.
7. Its ash.

We can judge as to the past meteorological conditions by an examination of the annual rings of wood, but the difficulty is to determine in the case of such woods as are to be found in the Hazzard collection, the year in which the wood was collected, whether at once or after the piece had lain on the ground for some time. We have, however, in the wood a valuable indication as to the years of drought and excesses of

rainfall. A recent writer in *Forest Leaves* (**5**: 51) describes the irregularity of growth very forcibly and gives tables supporting his statements. He says: "Having observed, in cutting various timber trees, the irregularity of growth at different periods of tree life, and being interested in the striking coincidence of these irregularities with the occurrence of certain forest fires, an examination was made. On counting back the rings to where these irregularities occur, it was found that these checks, scars and decreased growth of rings denoted an interference with the regular healthy life of the tree, the result of forest fires occurring at these periods."

Having determined the wood as used by the Indians, the next thing is to determine whether the plant is indigenous or introduced into the locality. The place from which it came can in most cases be definitely located by botanical explorations.

4. Ethno-botany is useful as suggesting new lines of manufacture at the present day. This is especially true of woven stuffs. Mr. F. H. Cushing has shown that by unraveling the woven frabrics a clue can be obtained as to the manner of weaving. He has succeeded in imitating skilfully a large number of Indian stitches and has discovered many interesting and suggestive facts in connection with the early weaver's art.

The especial province of ethno-botany is to study microscopically the nature of the fiber employed, as in many cases new methods of obtaining raw materials from hitherto undeveloped sources might be suggested. Not that we have not improved on the methods of our ancestors, but the sedentary Indians of the arid districts of our country were extremely ingenious and put to the best use all the plants round about them. Again, we may learn by this study new uses of plants of which we were in ignorance. A stimulant and nerve tonic new to materia medica has been discovered in this way. Dr. D. Webster Prentiss discovered the action of the drug popularly known as mescal button, which is yielded by *Anhalonium Lewinii*. He obtained the supplies through agent James Mooney of the U. S. Bureau of Ethnology, who resided among the Indians of the southwest, especially the Kioways, for many years. It is to the use of the mescal button by the Kioways in their religious ceremonies that the white man owes his present knowledge of the drug.

The Indians assemble in their council tents usually on Sat-

urday night, and seat themselves each with his supply of buttons, about a large camp fire, which is kept burning brightly. Button after button is swallowed from sundown until three o'clock A. M. Throughout the ceremony, there is no dancing or singing, but a continual monotonous beating upon drums is kept up by the attendants. The Indians sit in a blissful reverie for hours, enjoying the beautiful visions of color and other manifestations caused by the resulting intoxication. In fact, most of the plants which the new world afforded were made known in this way; tobacco, chocolate, the potato, maize, and tomato were first used by the Indians of North and South America and afterwards borrowed by white men.

One of the principal features of the equipment of every ethnological museum where ethno-botany is to be studied should be a collection of seeds, kept in glass bottles, and systematically arranged. The identification of all kinds of seeds collected from so many sources is impossible without such a collection.

"The seed collection of the Division of Botany, U. S. Department of Agriculture, is put up in glass specimen tubes without necks, and of two sizes, one 5^{cm} long and 1.5^{cm} in diameter, the other 10^{cm} long by 3^{cm}. In addition to the seeds, one or two capsules of the dry fruits are inclosed whenever possible. Fleshy fruits of our native wild plants are kept in a preservative fluid of some kind. Seedlings of economic plants in various stages of germination are also kept in alcohol for reference and study. The bottles are placed in cloth covered trays made of heavy binder's board. The trays for the smaller bottles hold 100 specimens. These are placed in one case, which is to contain also, so far as possible, herbarium specimens of the plants from which the seeds were taken. A card index to the collection is of great assistance in finding specimens."[5]

The equipment would not be complete without a series of microscopic slides, prepared to show longitudinal, transverse, and tangential sections of all our native woods. These should be indexed and catalogued in such a way as to be easily available for comparative use.

Lastly, an ethno-botanic garden should surround the museum building to provide living plants for study in connection with the objects of vegetal origin displayed in the museum.[6]

[5] Year Book of the Department of Agriculture **1894**: 408.

[6] HARSHBERGER, Museum and Garden. The Philadelphia Evening Telegraph. October 26, 1895. p. 5.

Only aboriginal American plants should find a place in such a garden. No plant can be found more graceful than maize, a grass associated with the myth of the aboriginal races of America and worthy the place as our national emblem. This plant has been little thought of for decorative purposes in our gardens. Yet it is decidedly ornamental and worthy of esteem. The sunflower, too, ought to be grown. The Indians recognized its value, for the Moquis and Supais planted it for food, and used the ground seed mixed with cornmeal as a dainty. The tobacco plant should not be forgotten, as it is decidedly ornamental.

The tomato with its crimson fruit, the pumpkin vine, the bean and the potato should find a place in some corner of the aboriginal American garden. The oak, yielding acorns, and the willow, dye stuffs, can be planted with good effect, while a pond, in which grow the arrow-leaf (*Sagittaria variabilis*) and yellow lotus (*Nelumbium luteum*), both furnishing aboriginal root-esculents, water cress, a salad plant, and wild rice, (*Zizania aquatica*), would serve to break the rigid outlines of the formal beds.

The plants should be arranged with reference to the Indian tribes which cultivated them. The plants of the Algonquin should stand apart from those of the Iroquois, those of the Aztecs from those of the Pueblos. Such a geographic arrangement is most desirable for educational purposes.

An arrangement according to the uses of the plants ought also be made. The strictly agricultural plants, such as corn, beans, pumpkins, etc., ought to be sown in one bed; the fiber plants, like basswood (*Tilia Americana*), sumac (*Rhus aromatica*), willow (*Salix lasiandra*), unicorn plant (*Martynia proboscidea*), yucca (*Yucca brevifolia*), in another; the dye plants, as alder (*Alnus incana*), celandine, smartweed, poke, white maple, gold thread (*Coptis*) is still another. The myth plants and medicine plants are important also, as showing the culture of the aborigines. They should by no means be excluded from this garden.

There can be no doubt, therefore, that such ethno-botanic gardens would stimulate greatly the interest in Indian plants, and at the same time they would be of the greatest scientific value. Nothing of the kind has ever been tried along the lines suggested, and such a garden would soon become a Mecca for those who desire to write upon our American plants and their uses among the aborigines.

University of Pennsylvania.

Notes on grasses.

GEORGE V. NASH.

My recent articles on "New or Noteworthy American Grasses," published in the *Bulletin* of the Torrey Botanical Club, seem to have caused considerable consternation among the agrostologists of the Department of Agriculture at Washington, judging from the haste in which they have criticised them. This haste has evidently led them into the commission of obvious errors, which would have been avoided had more care been taken in investigating the facts.

An exception is made to my disposition of *Agrostis brevifolia* of Nuttall. I am aware that until the type of this plant can be seen, absolute certainty of identification is impossible. The character given by Nuttall, to which your correspondent alludes, "culms solid and compressed . . . not terete but solid and ancipital," is one which is peculiarly applicable to the plant I have referred to Agrostis brevifolia, and which your contributor thinks is the *Vilfa Richardsonis* of Trinius. In the plant I have referred to Agrostis brevifolia the culms are solid, much compressed, and even ancipital. In the type of *Vilfa cuspidata* Torr., preserved in the Columbia College Herbarium, the culm, on the contrary, is terete with the exception of a slight flattening on one side, and never approaches ancipital in any degree. If this character is to be considered as "essential and decisive," it does not argue well for the equivalency of *Agrostis brevifolia* Nutt. and *Vilfa cuspidata* Torr.

Again, a lack of research is shown by your contributor in his disposition of Steudel's *Cryptostachys vaginata.* Steudel refers to the specimen, on which he founded his monotypic genus Cryptostachys, in the following words: "Panicum proliferum Hrbr. Amerc. un. it. 1837."[1] There is a specimen in the Columbia College Herbarium with a printed label bearing the above quoted words, and thus evidently a duplicate of the grass Steudel had in mind; it is undoubtedly the *Vilfa vaginaeflora* Torr. Steudel, like many others, applied Torrey's name to the wrong plant. But a careful consideration

[1]Syn. Pl. Gram. 181. 1855.

of the generic description given by Steudel should have availed to show that his Cryptostachys vaginata is *Vilfa vaginaeflora* Torr., for he says: "glumæ 2 . . . acuminatæ; valvulæ 2 membranaceæ pilosæ acuminatæ." These characters, especially the reference to the pubescence of the flowering scale (valvula), are found in Vilfa vaginaeflora of Torrey, and well distinguish it from my *Sporobolus neglectus*, in which the empty and flowering scales are never more than acute and perfectly glabrous. Besides the longer and relatively narrower spikelets in *V. vaginaeflora* Torr., another character serves well to distinguish these two related species. In Sporobolus vaginaeflorus the flowering scale in age is dull and usually mottled, while in Sporobolus neglectus it becomes white and shining.

The other of your correspondents seems to question the "validity" of some changes I have proposed, but he too disregards the facts. In reference to *Andropogon alopecuroides* L., it is perfectly evident that Linnaeus applied his name to a form with a twisted awn, for he uses the expression "aristis tortuosis." It makes no difference whether the twisting of the awn is of specific value or not. The only question is, to what form did Linnaeus give the name "alopecuroides." He has made himself clear on this point, as stated above. He also makes the following citation: "Andropogon culmo paniculato. Gron. virg. 133." On page 133 of Gronovius' Flora Virginica the above quoted words are found and appended is "Clayt. n. 601." I have been thus explicit, as a reference made by your correspondent to "Gronovius' number 133" leads me to believe that he has not investigated the matter very carefully, and the above words of explanation may help to set him right. He evidently inferred that the number 133 cited by Linnaeus referred to the number attached to some specimen. Had he looked into the subject, he would not have made this error.

In order to ascertain just what Clayton's no. 601 is, specimens of three distinct forms were sent to Mr. E. G. Baker at the British Museum, where Clayton's plants are deposited. He replied as follows: "Your no. 2 matches the Clayton type and as I thought perhaps you would like to see this for yourself I send a scrap of the type with Mr. Carruther's permission." This settled the matter conclusively. Bush's no. 160, collected in Missouri in 1893, and Kearney's no. 385,

collected in southeastern Kentucky in 1893, belong here. Whether the *Erianthus saccharoides* of Michaux is the same or not must remain doubtful until his type is seen.

As to the separation of Panicum into a number of genera, this of course must be a matter of individual opinion. If it can be divided into groups, why not call these groups genera? At all events consistency should be used in the treatment of the subject. If it is thought best to make one vast genus out of all these related groups, it would seem better not to draw any arbitrary lines. Why should not Paspalum be included also, as it approaches Eupanicum as closely as does Syntherisma? How large is to be this aggregation? Cannot Eriochloa, Anthaenantia, Oplismenus, Ixophorus, Pennisetum, etc., come in with equal propriety?

Nothing new is added by your contributor to the argument in reference to *Panicum latifolium* L. As the matter has been referred to, it may be well to call attention to the work of Doell, for whose judgment your correspondent seems to have respect, as evidenced by his remarks in relation to Syntherisma. Doell[2] has applied the Linnaean name latifolium to the tropical plant, and cites *P. divaricatum* L. as a synonym. Among the synonymy, and heading the list, will be found *Bambosulus latifolius* Sloane, Voy. *pl. 71. fig. 3.* As Linnaeus refers to this same figure[3] it is not difficult to understand what he had in mind and whence he derived the name latifolium. If Linnaeus had in his possession, at the time of the publication of his first edition of the species Plantarum, the plant which Munro says is attached to the sheet bearing the tropical plant, would he not have referred to it in some way? Linnaeus simply says: "Habitat in America." Under P. clandestinum, published on the same page, he distinctly states that he had that plant from Kalm. Is it not clear that he received from Kalm, after the publication of his first edition, the plant which Munro says was ticketed, "From Kalm, North America?" At Kew the name has been applied to the tropical plant, as shown by a number of specimens in the Columbia College Herbarium determined by Prof. D. Oliver; among them nos. 2,053 and 3,593, Jenman, from British Guiana.

Your contributor says that my *Panicum boreale* is a form of

[2] Mart. Fl. Bras. 2^2: 206. 1877.
[3] Sp. Pl. 59. 1753.

P. dichotomum, and may be separated as a variety of it. It is evident he has never seen the plant growing or he would hardly make this statement. Its habit is not that of P. dichotomum, but more that of *P. laxiflorum* Lam., from which it is abundantly distinct, both in technical characters and range. P. laxiflorum, so far as I am aware, does not occur north of Maryland. P. boreale, on the other hand, is a northern species, extending along the northern border of the United States. I have seen specimens from Newfoundland, Maine, Ontario, New York and Minnesota. It was collected by the writer at Cairo, in the Catskill Mts., N. Y., in 1893. It was quite plentiful there, and it was from field observations that my attention was called to its specific differences. The *P. laxiflorum* of Rand and Redfield's Flora of Mt. Desert (p. 175) belongs here.

The comments made on my disposition of *P. capillare* var. *minor* Muhl. are open to the same criticism made above in relation to P. boreale; your contributor is evidently not familiar with the plant as it occurs in the field. It is certainly as worthy of specific rank as *P. flexile* (Gatting.) Scribn. Are all these well-marked forms to be combined and this aggregation called a species? I will acknowledge this is an easy way to dispose of the matter, and entails little work on the author, but to those using the resulting work it is a constant source of confusion and disappointment.

Now as to the Ixophorus of Schlechtendal. Hackel[4] recognizes it, as being equivalent to Setaria, in the following words: *Ixophorus* Schlecht. ist eine einborstige *Setaria*." In the "True Grasses" of Scribner and Southworth, a translation of the above quoted words occurs and no comments are added, although comments do occur in other parts or the same work. Evidently the authors were satisfied with thsi disposition of it. Nor are the above parties alone in this treatment of the case. In the Index Kewensis the same view is maintained. Hemsley[5] gives, as synonyms of Setaria uniseta, *Urochloa uniseta* Presl. and *Ixophorus unisetus* Schlecht.

Columbia College, New York.

[4] Eng. und Prantl, Nat. Planz.-Fam. 7: 36. 1887.
[5] Biol. Cent.-Amer. **3**: 506.

Noteworthy anatomical and physiological researches.

On the twisting of the grain of pine.[1]

In 1854, A. Braun[2] published the results of extensive observations on the twisting of the grain in a large number of species of wood-producing plants, and offered an explanation for the phenomenon. The paper now under consideration contains the results of investigations on a limited number of allied species of conifers. Dr. Hartig agrees in part with Braun in his explanation, but does not agree with him as to the final cause of the twisting of the grain. The former assigns as the cause the peculiar manner in which the increase in the number of elements of the cambium occurs. As the woody axis of the tree increases in diameter the number of elements in the cambium cylinder at any height must increase correspondingly. This increase in the number of elements is secured not by division in a radial plane, but by transverse divisions. Usually these divisions do not occur at exactly a right angle to the long axis of the cell. As the two daughter cells produced by such a division, grow in length, the upper end of the lower one pushes its way upward and the lower end of the upper one grows downward, each insinuating itself between its mate and the neighboring element, separating to a slight degree the original elements of the cambium sheath, thus increasing its diameter.

These transverse walls are inclined both to the right and to the left from a radial plane. Between the relative members of these two kinds of wall and the twisting of the grain there is a close relation. Generally if the members are about equal the grain is straight. If a large majority of them incline to the right the grain winds in that direction; if to the left, the winding is in that direction. This is explained in the following manner. After each transverse division, if the wall inclines to the right, the tendency is for the upper end of the lower daughter cell to incline to the right, and for the lower end of the upper daughter cell to incline to the left. If now

[1] Hartig, Robert: Ueber den Drehwuchs der Kiefer. Forstlich-naturwiss. Zeitschrift **4**: 313–326. Ag. 1895.

[2] Braun, A.: Ueber den schiefen Verlauf der Holzfaser und die dadurch bedingte Drehung der Bäume. Sitzber. der kgl. pr. Akad. der Wiss. Berlin, 1854.

other divisions of the elements occur in the same manner and in quick succession, the cells will all soon be inclined to the right, and in like manner if the walls incline to the left, the cells will incline to the left. The elements of the wood will be inclined as those of the cambium are inclined.

In all of the specimens examined, if any twisting of the grain occurred during the first thirty years of the life of the tree, such twisting was found to be to the left. In about half of the specimens the twisting in this direction continued throughout the life of the tree. In the other half twisting did not make its appearance until well along in the life of the plant (then to the right) or changed from the left to the right in from thirty to one hundred twenty years. The inclination of the long axis of the elements from a radial plane varied from one to ninety degrees. In a little more than half of the specimens the angle of divergence increased regularly with the age of the tree.—L. S. CHENEY.

The mechanics of curvature.

The much vexed question of the curvature of organs in response to various stimuli is again to the front, and a slight advance in the solution of the chief problem, *i. e.*, the immediate cause of the curvature, may be claimed. Noll in a recent contribution[1] meets the specific objections offered to his previous work[2] by Kohl[3] and Pfeffer.[4]

The principal theories which have been successively advanced in explanation of curvatures are chiefly as follows: Sachs attributed it to the exaggerated growth in length of the tissues on the side whose surface became convex in outline; DeVries to an induced heightened turgor of the convex side; Wortmann, in 1887, to the thickenings of the membranes of the concave side and aggregation of protoplasm in the cells limited by them, and consequences in growth extension. In the large amount of critical work following this last contribution it was established that the migration of the protoplasm and the thickening of the membranes on the concave side were attendant upon but bore no causal relation to cur-

[1] Ueber die Mechanik der Reizkrümmungen. Flora **81:** 36–87. 1895.

[2] Beitrag zur Kenntnis der physikalischen Vorgänge, welche den Reizkrümmungen zu Grunde liegen. Arb. d. bot. Inst. z. Wurzburg **3:** 496. 1888.

[3] Die Mechanik der Reizkrümmumgen. Marburg. 1894.

[4] Energetik der Pflanzen. Leipsic. 1893.–Druck und Arbeitsleistungen durch wachsende Pflanzen. Leipsic. 1893.

vature. According to the results of Noll's recent researches it seems somewhat conclusively demonstrated that the stimulus induces an increased plastic and elastic extensibility of the longitudinal membranes of the side of the organ afterwards becoming convex through the activity of the protoplasm, that these membranes extend in length from the pressure of turgidity, which is equal throughout the entire cross section, but the membranes of the concave side are unaltered and do not respond farther to it. That the extension of the membranes of he convex sides is not growth is shown by the fact adduced by Noll that they not only become thinner during the extension but do not increase in dry weight. The alterations in the properties of the cell wall which permit the extension are accompanied by changed reactions to staining substances. The fixation of the elastically and plastically extended cell walls of a curved organ is compared to the vulcanization of a stretched membrane of india-rubber; the protoplasm produces a substance which "vulcanizes" the extended wall and prevents the reflexion of the old curvatures to the initial stature of the organ when plasmolysed.—D. T. MAC DOUGAL.

Selection of organic foods by plants.

In a recent article, Pfeffer[1] has taken up the question of selection by plants from organic foods offered. If two carbon-containing compounds, each of which is present in a quantity sufficient to completely satisfy the demand for this kind of food, be offered to a plant at the same time, will both of these substances, either of which is capable of replacing (and thus protecting) the other, be used; and if this protection takes place, to what degree does it occur?

The experiments were conducted exclusively with the lower fungi, in most cases with *Aspergillus niger* and *Penicillium glaucum*. In the first series of experiments, two carbon-containing compounds of rather unequal nutrient value, dextrose and glycerine, were added to the nutrient solution in various proportions and the fungi in pure cultures were cultivated therein. The general result was that a choice was exercised in taking up the necessary carbon-containing material. Both were somewhat used, but the better food, the dextrose,

[1] PFEFFER, W.: Ueber Election organischer Nährstoffe. Jahrb. f. wissensch. Bot. **28:** 205. 1895.

was drawn on to a far greater extent than the glycerine, the latter being thus protected. In case the dextrose was present in small quantities, it was totally consumed before the close of the experiment and the glycerine was then used until the close. Although dextrose was able to protect in great part the glycerine, still, even when present in abundance, it did not do so completely.

When lactic acid took the place of glycerine, a similar general result was reached.

In case acetic acid, in food value approximately equal to glycerine and lactic acid, was offered with dextrose, a different result was reached. Although a poorer food than dextrose, the consumption of acetic acid was large, in cases exceeding, in ratio to the quantity offered, that of the dextrose. Here, the better food did not protect the poorer from use nor did the poorer protect the better. Why acetic acid is thus consumed at the same time with the dextrose, is a question which the author does not attempt to answer. He suggests, however, that it may be of special availability for the satisfaction of some single function. The suggestion of the satisfaction of single functions does not receive full discussion but indicates interesting possibilities.

When peptone took the place of dextrose in experiments similar to the above, very similar results were obtained. On the whole, peptone protected the poorer food more completely than dextrose.

By growing fungi in a mixture of dextro- and lævo-gyrate tartaric acids very interesting results were obtained.

While Pasteur, in 1858, found the dextro-acid was used, leaving the solution lævogyrate, Pfeffer found that while a majority of the forms used in his experiments acted similarly, almost as many showed no choice, using both kinds in like quantities. One form, a bacterium, chose the left-handed acid, leaving the solution dextrogyrate.

Pfeffer considers the causes influencing selection to be largely referable to plant regulation and therefore, a function of irritability.

In case of widely differing diosmotic properties, the material penetrating more rapidly than the other, though perhaps no better food, will supply the demand to a larger degree.

The stimuli prompting to a choice arise either from the plant's own products or from the substance offered. The

quantity of reserves present and the concentration of the waste products belong to the former class of stimuli. The chemical nature, the food value of the substance and the mass offered are of the latter class.

Generally speaking, the better food is taken before the poorer, it being kept in mind that the individual peculiarities of the plant determine what constitutes a substance a good or a poor food. The extreme diversity as regards the chemical nature of substances used to supply the carbon demand is cited.

In order to speak more precisely concerning the values of materials used as food, Pfeffer introduces the "economic coefficient" of a substance for any plant in question. The "economic coefficient" of any substance for a given fungus is the amount of the dried fungus mass produced from the consumption of 100 parts of the food material.

The coefficients of dextrose and glycerine for the two kinds of fungi most used are as follows:

	Dextrose.	*Glycerine.*
Aspergillus niger	43	20
Penicillium glaucum	33	15.

RODNEY H. TRUE.

On the prevailing ombrophilous character of the foliage of tropical plants.[1]

A review of Wiesner's preliminary studies upon this subject in Europe was given in this journal in March, 1895. The present paper contains the results of his observations in Buitenzorg. It was proved, according to his previous experiments, that a distinction can be made between "ombrophobic" and "ombrophilous" foliage, and it was to be expected that this last form, the ombrophilous, would be the prevailing one in the moist tropical climate of Java.

The observations of Professor Wiesner show now, that the majority of the native and cultivated plants in Buitenzorg have ombrophilous leaves, but he observed, also, that ombrophobic leaves are not excluded. There are several plants of decidedly xerophilous character which tolerate the damp climate in this place. This is further illustrated by the fact that there is in the Buitenzorg garden a large group of Cacteæ and cactus-like Euphorbiaceæ, which thrive well in a place

[1] WIESNER, JULIUS: Pflanzenphysiol. Mittheilungen aus Buitenzorg. III: Ueber den vorherrschend ombrophilen Charakter des Laubes der Tropengewæchse. Sitzungsber. d. K. Akad. d. Wiss. math.-naturwiss. Classe **103:** 169–191. 1894.

which is exposed to the full effect of the sunlight. Among these are gigantic specimens of *Cereus pruinosus* and *cinerascens*, which have attained a height of six meters, a fact that seems to prove that such plants also may be able to tolerate a damp atmosphere. The author calls attention to the fact that the depression of transpiration in Buitenzorg is not so great as formerly stated by certain botanists. Indeed, it is not unusual to see that several plants show the effects of the exposure to the sun by the wilting of their leaves. The strong imbibition of the cell membranes of the leaves allows a considerable transpiration to take place even in an atmosphere which is almost saturated with moisture. It is, therefore, not correct to suppose that the plants in the damp climate of Java are only able to transpire in a very small degree. There are in Java several plants which really need considerable evaporation but seem to thrive well in the moist atmosphere. This is due to the fact that such plants have gradually changed their character and very often, also, their habit. This is, for instance, the case with the cultivated rose, which has ombrophobic foliage, and which only produces very few leaves and small flowers in the garden at Buitenzorg. But the skill of the cultivator has nevertheless succeeded in producing a few specimens with large and odorous flowers. This is interesting, since, according to Teijsman,[2] there is not a single native species of *Rosa* in Java. Several varieties of these cultivated roses have changed their ordinary habit by keeping their young leaves hanging for quite a long time and by being deep red from anthocyan, before they attain the green color. Some other varieties, which were unusually leafy, showed that the ombrophobic character of the normal leaf had been modified in these. The tea-roses thrive well as a rule, but there are a few varieties of these which have, so far, entirely failed to develop.

The author discusses a number of other plants, the foliage of which is ombrophobic, and which shed their leaves after a continuous rainfall. Such plants are *Oxalis Plumieri*, *O. corniculata*, species of *Cassia*, *Acacia*, etc. It seems, altogether, to be characteristic of such plants, that they drop their leaves much earlier than those with ombrophilous foliage. But it has also been shown in all plants that the om-

[2] Teijsman: Catalogus plantarum quæ in horto bot. Bogor. coluntur. 250. Batavia 1866.

brophilous character becomes lost by age and that it is not acquired until at a certain stage of the development of the leaf.

A peculiar case is mentioned to show how *Mimosa pudica* is able to protect itself against the rain. The leaflets are ombrophobic but escape the effects of the rain by the closing of the entire leaf. The leaflets themselves are, however, quite easily wetted when separated from each other, and the sensitiveness of this plant seems to be an adaptation for withstanding an excessive rain.

In regard to the ombrophilous foliage, the author confirms the observations of Stahl.[3] These leaves show a distinct relation to exist between their shape and their easily wetted surface, viz.: the presence of hairs, a furrow-like deepening above the veins, the dripping-point, etc. It is, also, interesting to note the importance of the hanging of young leaves, which is commonly observed in Java. This seems to be explained by the fact, that such leaves are ombrophobic when young, but become ombrophilous at a later stage, and then begin to raise themselves in a more or less horizontal position.—THEO. HOLM.

[3]STAHL, E.: Regenfall und Blattgestalt. Ann. du Jardin du Buitenzorg—11: 98.

BRIEFER ARTICLES.

Accessory Buds.—*With Plate XIV.*—The axillary buds of *Spiraea sorbifolia* L. are very conspicuous and are especially interesting because of the pair of large collateral accessory buds which are usually associated with them. There is no better plant than this for studying the nature of accessory buds, if taken when these buds are just making their appearance, say in June or July. During the winter the three buds seem to have no connection with one another, but when small the accessory buds are plainly seen to arise from the axils of the first two bud-scales of the axillary bud. (Fig. 1.) Occasionally only one accessory bud makes its appearance, and sometimes when both accessory buds are present the normal axillary bud aborts and results in apparently two axillary buds entirely separated from one another.

No other Spiræa examined had accessory buds, but other species belonging to the order Rosaceæ were examined, and wherever accessory buds occurred they were collateral with the axillary buds, and evidently axillary to the lower bud-scales.

In a cultivated species of cherry some of the nodes have simple axillary buds while others have one or more accessory buds of equal or almost equal size with the axillary bud; but as between these two conditions there was every degree of development present. The origin of the accessory bud was plainly seen to be the same as those of Spiræa.

There are no accessory buds on the wild cherry (*Prunus serotina* Ehrh.), but on examination of the rings left by the falling of the bud-scales at the beginning of this year's growth a small bud is seen in each of the lower scars. These buds would have been the accessory buds had they been conspicuously developed during the existence of the bud to whose scales they are axillary.

Accessory buds in Caprifoliaceæ, when present, are superposed and their character, if the same as in rosaceous plants, is not so apparent. *Diervilla trifida* Moench. gives excellent examples of this arrangement of the buds (fig. 3). Here two buds appear above each axillary bud and in case the axillary bud is in any way destroyed, the lower accessory on that side increases in size till it is equal to the axillary bud of the opposite side (fig. 4). The same arrangement is also found in several cultivated varieties of honeysuckle, as *Lonicera Halliana* L., *Japonica* and var. *aurea*, etc., while our native honeysuckle (*L. Sullivantii* Gray) has no accessory buds.

In all the representatives of the Leguminosæ examined where acces-

SHULL on ACCESSORY BUDS.

sory buds are present, the axillary bud is removed a short distance above the axil of the leaf and a single accessory bud is situated in the axil. This is distinctly seen in *Amorpha fruticosa* L. and *Cercis Canadensis* L. In the honey locust (*Gleditschia triacanthus* L.) the thorns are somewhat removed from the axils and a small bud is situated in the axil of the leaf. It is thus evident that the thorns arise from the true axillary buds and the small bud in the axil of the leaf is an accessory bud.

In Vitaceæ is found another very striking proof that accessory buds are not anomalous in character but are axillary to the bud-scales or the undeveloped leaves in the bud. Here a glance at any of the buds will show a single accessory bud with the apex just apparent above the outer bud-scale. This is best seen in *Ampelopsis quinquefolia* Mx. No one would, from a superficial examination, suppose more than this one accessory bud to exist, but by sectioning the bud one and frequently two other such buds may be seen in different stages of development (fig. 10).

August F. Foerste has observed[1] a tendency of certain abnormal conditions to recur at more or less regular intervals in a specimen of elm studied by him. Much greater regularity is shown in the recurrence of definite nodal characters in Ampelopsis. The repeated series consists of three nodes beginning with the third node from the axis from which any ramial division in question arises. At the first node of this series we observe on one side the stem nothing but the leaf-scar, on the opposite side the remains of a tendril, a flower-cluster, or the scar left by the falling of one or the other of these. The second node of the series is frequently precisely similar to the first but on vigorous branches usually presents a compound bud in the axil of the leaf-scar. At the third node of the series there is no scar or organ opposite the leaf-scar while in its axil is a strong axillary bud with its accessories well developed.

There seems to be a gradual increase of power from the first to the third node of the series. At the first node the terminal bud produces either a tendril or a flower-cluster which becomes opposed to the leaf by the development of the axillary bud into the succeeding internode of the axis, and the accessory bud fails to appear. At the second node sufficient power may have developed to produce in addition to these an accessory bud in the position usually occupied by the axillary bud. This bud does not materially differ from the true axillary bud except in the degree of development. A section of it shows the two or three accessory buds within but they are not as far ad-

[1] Botanical Gazette 19: 463. 1894.

vanced as the accessories of the true axillary bud. In the third node where the energy seems to reach a climax the terminal bud produces the succeeding internode and the remainder of the power is spent in forming and protecting a strong bud whose destiny is to develop a secondary axis the following season. The year's growth never ends with an uncompleted series, the crowning bud always belonging to the third node.

The wild grape (*Vitis cordifolia* Mx.) is precisely similar to Ampelopsis in all these characters, but in the cultivated varieties examined considerable variation was found to exist in the periods of recurring nodal characters. The node at which the terminal bud continues the main axis occurred in these varieties at intervals of three, five, seven or even nine, and though usually at odd intervals would sometimes occur in the fourth or sixth places. This variation is probably due to the unnatural conditions attendant upon cultivation, especially such as pruning.

Prof. Alphonso Wood considered[2] the tendrils of the grape abortive or transformed flower-stalks. This is not necessarily true. Both are axial developments arising from terminal buds and hence occupy similar positions, but it is no more correct to say the tendrils are abortive flower-clusters than that the flower-clusters are modified tendrils, which latter would be the more probable if either were true, because tendrils are produced during the entire growing season while flower-clusters appear for a very short interval only.

The accessory bud of *Juglans nigra* L. and species of Carya is very small and arises just below the axillary bud in the groove at the base of the petiole. Observations thus far indicate that the relative position of axillary and accessory buds forms a family character. Though *Juglans cinerea* L., being rather rare in this section, has not come under the observation of the writer, it seems to him a fair question whether Prof. Asa Gray may not be mistaken in stating[3] that in the butternut "the true axillary bud is minute and usually remains latent, while the accessory ones are considerably remote and the uppermost which is much the strongest, is far out of the axil; this usually gives rise to an extra-axillary branch." In no observed case are branches regularly produced by accessory buds, their office being simply to take the place of the axillary bud in case that is destroyed, or normally develops into some other organ, as do the axillary buds of Diervilla, which develops the fruit.

Possibly the upper and stronger bud in the butternut which usually

[2] Class Book of Botany 66, 75. 1880.
[3] Gray's Botanical Text Book. 1: 45. 1879. [6th ed].

"gives rise to an extra-axillary branch" is the true axillary bud, as the upper bud plainly is in Amorpha fruticosa, Cercis Canadensis, and the above mentioned Juglandaceæ.—GEO. H. SHULL, *Sulphur Grove, Ohio.*

EXPLANATION OF PLATE VI.—Fig. 1. Axillary bud of *Spiræa sanguisorba* L., the accessory buds just making their appearance.—Fig. 2. Same, the axillary buds fully developed as seen in the winter.—Fig. 3. A node of *Diervilla trifida* Moench.—Fig. 4. The same. One of the axillary buds has been destroyed and the leading accessory bud has taken its place.—Fig. 5. A node of *Cercis Canadensis* L.—Fig. 6. A node of *Amorpha fruticosa* L.—Fig. 7. Node and thorn of *Gleditschia triacanthus* L.—Fig. 8. A node of *Juglans nigra* L.—Fig. 9. A node of *Ampelopsis quinquefolia* Mx.—Fig. 10. A section of the bud of same.—Fig. 11. The first two nodes and the recurring series of three nodes of *Ampelopsis quinquefolia*.

Relations of cutinized membranes to gases.—During the course of some experiments on the relations of plant membranes to gases, I had occasion to make an estimation of the rate of diffusion of CO_2 through a grape skin, and obtained a somewhat unusual result. In this experiment a cleaned skin of a Concord grape was fitted, by means of sealing-wax, to one end of an open glass tube 30^{cm} in length and 5^{mm} internal diameter, filled with boiled water, inverted in a dish of mercury, and the water displaced by washed carbon dioxide (MacDougal, Exp. Plant Physiology 36, 37. 1895). By the exosmose of the gas the mercury column was slowly drawn upward into the tube, for seven days at the rate of 2.5^{cm} per day, and six days at the rate of 1^{cm} per day. At the end of this time the meniscus of the mercury column was against the lower surface of the membrane. The column remained stationary for eleven days and then slowly began to fall until ten days later it became stationary 1^{cm} below the membrane. It retained its height with barometric and thermometric variations, from Nov. 1, 1894, to Dec. 10, 1895, when the apparatus was accidently shaken so roughly that the vibration of the mercury column ruptured the membrane and the column fell in a few minutes. An examination of the grape skin revealed a heavy cutinization of the outer walls as well as in the ten to fifteen layers of cells of which it is composed. The inner layers of the epidermis in some instances showed intercellular spaces, so that only the extreme outer layers can be taken into account in the consideration of the resistance to filtration, which in the present instance lasted thirteen months under pressure of 29^{cm} of mercury. This absolute resistance of the membrane to filtration for such a length of time has not been duplicated in any case whose records are accessible to the writer. Miss Golden details experiments with the resistance of grape skins to filtration under pressure of 44.5^{cm} of mercury for nine days (Proc. A. A. A. S. 43: 277. 1895.) and Wiesner

found in a similar experiment a grape skin which sustained a mercury column 70^{cm} in height for seventy-five days. The membrane is believed to have shown an absolute or nearly absolute resistance to filtration by atmospheric gases during the time mentioned in my experiment, since the upper surface of the column and the tube showed a discoloration indicative of the decay of the coloring matter from the lower side of the membrane. The gas evolved during the disintegration would be of sufficient amount to allow the fall of the mercury column.—R. N. Day, *Minneapolis, Minn.*

Hamamelis Virginiana.—Notes in a recent number of the Gazette regarding the dissemination of seeds of *Hamamelis Virginiana* recall my first acquaintance with its powers of propulsion.

In August, 1890, a visiting friend to whom the plant was new brought a branch to the house and placed it over a mirror. The next afternoon (some twenty-four hours later) as I was sitting alone in the room my attention was called to occasional cracking sounds which investigation proved to be caused by the propulsion of these seeds.

By evening most of the capsules were found to be empty, and those not so were emptied during the following day. No measurements were taken, but I distinctly remember that a number of the seeds were thrown to the opposite side of a 17-foot room.

I mention this as showing that the propulsive power is acquired as the capsule becomes dry, even though the stage of maturity is not reached.—Bessie L. Putnam, *Harmonsburg, Pa.*

EDITORIAL.

WITH THIS NUMBER the BOTANICAL GAZETTE passes into the possession of the University of Chicago. The only change that will be apparent to readers will come from the much larger opportunity of serving botany, for the same editors will remain in charge, and the general purpose of the journal will continue to be the same. The establishment of a Department of Botany, and the appointment of the senior editor as head professor, justifies the University of Chicago in assuming financial responsibility for the publication of the GAZETTE, which has been brought to its present standing by private enterprise. That this has been possible demonstrates its adaptation to the needs of American botanists, as well as their cordial appreciation. Now that it is about to enter upon a period of strong financial support it expects to meet these needs in the fullest possible way, and more abundantly deserve the good-will of its readers.

It should be clearly understood that the GAZETTE is to be even more freely open to the botanists of the world than it has been in the past. It is not to be the organ of the botanical department of any university, but it belongs to all botanists everywhere. Its relation to the University of Chicago is simply to bring it that permanence and possibility of development which the present condition of botanical science demands.

* * *

THE FIRST paper in the last number of the *Minnesota Botanical Studies* might furnish an excellent text for a homily upon the abuse of the footnote. On one page, containing less than 300 words, there are no less than twenty footnotes! When the author says of Cypripedium, "The genus is represented in Rússia[44], Germany[46] and other portions of Europe,"[46] she feels impelled to cite Ledebour and the Bot. Jahresberichte to establish these well-known facts. It would be almost as appropriate to cite the Century or Standard dictionaries as authority for the very words of the sentence. Such a volume of unnecessary references suggests too much the strutting turkey with feathers erected to produce an effect of size and weight beyond his real substance.

FOR THE LAST paper entitled "A study of some Minnesota Mycetozoa," Mr. Sheldon deserves severe censure. We have known Mr. Sheldon heretofore as a student of the very difficult genus Astragalus, in which his work has received sharp criticism, some undeserved and some doubtless deserved. His appearance as a reviser of genera in the far more obscure Mycetozoa is therefore a great surprise. It is quite impossible to believe that a student of as few years standing as the author of this paper can be entitled to speak upon both Astragali and Mycetozoa. Had Mr. Sheldon confined his publication to a list of Minnesota Mycetozoa, under names accepted by any monograph, he would have done a real service. But when in a list of forty-two species he proposes twenty-five new names (with long lists of synonyms in which we can have no confidence), he not only stultifies himself but does irreparable harm. The case, however, is even worse. Not content with dumping about the Minnesota species the rubbish of worthless names constructed from book synonymy, Mr. Sheldon proceeds to "indicate" the nomenclature of sixty-odd species with which he had no immediate concern. It is difficult to refrain from imputing unworthy motives in censuring such a flagrant abuse of liberty of publication.

While Mr. Sheldon is the chief sinner, we cannot but feel that the editor of the *Minnesota Botanical Studies* by permitting the publication of this paper, has, not only done harm to the science of taxonomy, but has put into the hands of conservatives in nomenclature a keen weapon which they will not hesitate to use against the advocates of reasonable reforms.

CURRENT LITERATURE.

Two new books for secondary schools.

Probably the most puzzling problem in botanical book-making is the preparation of a suitable book for secondary schools. The factors in the problem are limited time, little or no equipment and poorly trained teachers. In the higher stretches of education these factors disappear or at least such an assumption can be made. Many have been the attempts to solve the problem, but in most cases the demand for time, equipment, and training has been larger than the supply. Professor T. H. MacBride, of the University of Iowa, is the latest to enter this field with his "Lessons in Botany."[1] His theory is to be of the greatest advantage to the greatest number, and hence he seeks to give the necessary science training through the use of what are called "the common plants." This of course means the plants of popular knowledge. In accordance with this theory trees are first introduced by a study of buds, followed by stems, roots, leaves, inflorescence, etc. Then follows a series of types, with no special sequence further than convenience in securing the material. The last six of the fifty-four lessons are given to cryptogams.

The text is almost entirely in the form of laboratory directions, only those portions of it being didactic which are necessarily so to fill out the subject under discussion. Professor MacBride has followed out his theory in a very systematic and clear way, and the book will no doubt be very useful because usable, in the secondary schools, certainly far more so than many of its predecessors. We do not agree with Professor MacBride's position that the "natural order" of presentation is opposed to the "logical order," and that it is more natural for students to take up a subject in the order "in which all science has been developed." If the "natural" order of presentation, which is the artificial one, is to be followed rather than the "logical" order, which is the natural one, only until teachers of the secondary schools have been sufficiently trained to present the plant kingdom from the standpoint of its evolution, that is, from the standpoint of nature, we are content. We question though whether even this is necessary.

The other book[2] has been prepared by Mr. Bergen, the teacher of

[1] MacBride, Thomas H. — Lessons in elementary botany for secondary schools. Small 8vo. pp. xii + 233. Boston: Allyn & Bacon. 1896. 60 cents.

[2] Bergen, J. Y.—Elements of Botany. 12mo. pp. viii + 275 + 57. Boston: Ginn & Co. 1896.

biology in the English high school, Boston. It is divided into two separately paged and indexed parts, the first treating the topic announced in the title, while the second consists of a very much abbreviated flora (with a key), including "a few of the commonest spring flowers of the northern and middle states." This part, which is a mere publisher's trap to catch the unsophisticated teacher or school board, may be dismissed as not representing the author's ideas and as unworthy serious consideration.

The most praiseworthy feature of the book is the point of view, and the method advocated and necessitated if the book is adopted. The point of view of the author is the only one from which the mass of students will obtain any adequate conceptions of plant life. The plant is discussed as a living thing having relations to other living things and to its physical environment. The structure of this being is examined only so far as it is related to plant dynamics. This presentation of morphology and physiology is combined with directions for dissection or experimentation illustrating the points discussed. It is the first book of the kind which has come to our knowledge and its plan must be commended as most excellent.

But the execution leaves a good deal to be desired. In the first place the author has been unable to skake off the traditions of the past as fully as he ought to have done. This is manifest in the relegation of the "flowerless" plants to a separate chapter of twenty-seven pages, where they receive wholly inadequate treatment. It is further shown in the disproportionately elaborate treatment of the flower. To the morphology of the flower and inflorescence as much space is given as to all the cryptogams, while forty pages more are devoted to fertilization and the fruit. One sees also the survival here and there of the antiquated features of the earlier books, *e. g.*, in the discussion of the structure of those stems and roots only which have undergone secondary thickening; in the retention of "exogenous" and "endogenous" as designating stem structure; in the description of the bud as a cluster of leaf rudiments with no reference to the fundamental importance of the growing point, etc. The book is also curiously lacking in logical arrangement and in definitions. Nowhere is the student told what a leaf, stem or root is, nor is he led to discover how he can distinguish the one from the other.

But it must not be supposed that the book is largely bad. By no means. In the combination of a large amount of physiology and physiological experiments with the morphology and dissection; in the general accuracy of what is given (though there are some slips here); and in the selection of the abundant illustrations the book is a distinct advance upon its predecessors.

It is worth while noting the fact that both books are entirely dependent upon accompanying laboratory work, as indicating the profound change which is coming over the botanical teaching in high schools.

Plant breeding.

The second volume of the "Garden-Craft Series," by Professor L. H. Bailey, is before us in tasteful dress.[1] It deals with the very interesting questions regarding the breeding of plants to secure fixation of desirable features. The book consists of five lectures, covering topics presented to the author's students.

In the first lecture the causes for the appearance of new forms of plants, and the fundamental methods for fixing these forms and making them permanent, are presented. The influence of soils and methods of treatment, effects of climate, the change of seed, etc., are discussed. The second lecture expounds the philosophy of crossing as well as its advantage as a means of originating new varieties. In the third lecture specific rules for the guidance of the cultivator are laid down, none of which are to be found particularly set forth in this connection in other readily accessible writings. The fourth lecture consists of translations of Verlot's classification of varieties of ornamental plants, Carrière's discussion of bud variation, including a list of bud varieties, and Focke's chapter on the characteristics of crosses. In the final lecture, directions for the cross pollination of plants are given in detail, with illustrations. A brief glossary and a good index are appended.

We particularly commend this book to botanists, who have too long let the garden fence bar them from the study of some of the most interesting and instructive phenomena of plant evolution. The first three chapters will be found of especial interest and value.

We must take exception, however, to Professor Bailey's statement that "the ultimate unit or individual in growing plants is the bud and the bit of wood or tissue to which it is attached" (p. 8). And also to this: "This unit [in which variations arise] is the bud and the seed, —the one sexless, or the offspring of one parent; the other sexual, or the offspring of two parents." The confusion regarding the sexual phase of seed plants ought not to be perpetuated, even in popular books, as it is throughout this book. Regarding this topic it is quite possible to be accurate without being abstruse, and the sooner we cease to call flowers "sex organs" the better, for gardeners as well as for botanists.

[1] BAILEY, L. H.—Plant breeding. Garden-craft series, vol. II. 12mo. pp. xii+293. figs. 20. New York: Macmillan & Co. 1895. $1.00.

But this morphological shortcoming will trouble too few, while the lucid and vigorous presentation of the chief matters will interest many, we hope.

General biology.

A second edition of the General Biology published by Professors Sedgwick and Wilson[1] ten years ago has given opportunity for a thorough revision and considerable changes in plan. The original plan provided for a general discussion of the fundamental properties of protoplasm and the forms of cells, followed by the thorough study of a plant (for which the bracken fern served as a type) and an animal (the earthworm). The difficulties in the use of the book arose from the exceedingly varied material necessary for the laboratory work on the first part of the book.

The chief changes in the present edition consist in the elimination from the body of the text of all laboratory directions, in lieu of which suggestions are made to teachers in an appendix; in the transfer of the study of the animals to precede the plants; and in the introduction of a series of unicellular animal and plant types.

The first change we think wise, but regret that the suggestions are too brief for those who need them at all. The second change, on the plea of the "ease with which the physiology of the animal can be approached; there can be no doubt that beginners find the nutritive problems of the plant abstruse," seems to rest upon a false premise. If beginners find the vital phenomena of a plant difficult to grasp, the fault lies with the teacher and the presentation—not with the character of the phenomena, which are vastly simpler than in the animal. The authors, who are zoologists, state their own experience, probably, and the reason may be valid in such cases; but their assertion that "there can be no doubt" is too strong for botanists to accept.

The introduction of the unicellular plants, protococcus, yeast, and bacteria, after the study of Pteris, seems to us an anomaly. Perhaps if a study of the physiology of protococcus preceded that of the bracken fern the authors would not find the latter so abstruse.

For the material of the book, the clear illustrations and the lucid style we have only praise.

Minor Notices.

YAKUTAT BAY, Alaska, was explored by Mr. Frederick Funston in the summer of 1892, under the direction of the Division of Botany of the Department of Agriculture. The results are just now published

[1] SEDGWICK, WM. T., and WILSON, EDMUND B.—An introduction to general biology. Second edition, revised and enlarged. 8vo. pp. xii + 231. figs. 105. New York: Henry Holt & Co. 1895.

(Jan. 15th) as vol. 3, no. 6, of the "Contributions from the U. S. National Herbarium." An interesting field report is presented by Mr. Funston, which well points out the peculiarities of the region. Mr. Coville, Chief of the Division, makes the botanical report, which consists of a catalogue of the 137 vascular species and varieties, and 27 bryophytes, with habitats and critical notes. We regret exceedingly to note that this government publication has adopted a new family nomenclature. A certain amount of discussion and agreement may be claimed in support of the use of the rules of the Botanical Club, but to supplant such names as Cruciferæ, Leguminosæ, Umbelliferæ and Compositæ, by Brassicaceæ, Fabaceæ, Ammiaceæ and Carduaceæ is the merest pedantry, and is straining after uniformity when uniformity is not necessary.

MINNESOTA BOTANICAL STUDIES, part 7, contains five papers. (1) On the genus Cypripedium with reference to Minnesota species, by Henrietta G. Fox, deals with the formally adopted state flower, with descriptions and geographical distribution in the state of the six species of the Atlantic region. (2) Poisonous influence of various species of Cypripedium, by D. T. MacDougal, in which he confirms his earlier observation, showing that the poisonous action is due to glandular hairs. (3) Tree temperatures recorded by Roy W. Squires. (4) Some Hepaticæ of Minnesota, by John M. Holzinger, is a list of 25 species. (5) A study of some Minnesota Mycetozoa, by E. P. Sheldon. Further editorial comment on nos. 1 and 5 will be found on p. 171.

A REPORT on collections made in 1894–95 by the Botanical Survey of Nebraska, conducted by the Botanical Seminar of the University, has just been issued. It is devoted to descriptions of new fungi and a list of additions to the reported flora of the state. The new species number fifty-five and the additions bring the state list up to 3,196 species.

MR. JAMES M. MACOUN, Curator of the Herbarium of the Geological Survey of Canada, is publishing a series of contributions from the herbarium. Numbers V, VI and VII are before us, reprints from the *Canadian Record of Science*, and contain additions to the flora, new stations, revised nomenclature and critical remarks.

THE "BOTANICAL SEMINAR" of the University of Nebraska has issued part 21 of its "Flora of Nebraska," containing the *Rosales*, by Mr. Rydberg. The handsome typography, good plates, and full treatment of the other parts continue. The statement of the relationships of various groups is full of interest, and careful synonymy blazes the way for those unfamiliar with the new nomenclature.

OPEN LETTERS.

Is publication of botanical and zoological papers in microscopical journals justifiable?

In the October GAZETTE in the column of "Notes and News," is this statement: "Botany and zoology are becoming badly entangled again with 'microscopy.' As something that deals with methods, the latter has an important place; as dealing with botanical and zoological results, it is out of its domain." Why the author of this paragraph makes use of the word "again" is difficult to see, for there has certainly been abatement neither in the recent nor in the remote past in the use of microscopical journals and proceedings for publication of biological papers. Indeed so far as my acquaintance with these journals goes there has been a steady increase of material such as the GAZETTE deems out of its proper place.

Is such publication justified by precedents? It is due the American Microscopical Society to say that it is by no means the first nor the only nor by any means the chief sinner in this respect. If the practice of putting biological papers into journals bearing a title indicating only that they are *microscopical* journals is to be condemned, then the leading English, American, and German microscopical periodicals at once become missionary fields for the GAZETTE note-writer.

A perusal of the following periodicals will show that papers dealing with botanical and zoological results predominate in all, and in some predominate almost exclusively. Other equally reputable titles might be added but this seems hardly necessary. Quarterly Journal of Microscopical Science, Journal of the Royal Microscopical Society, Journal of the New York Microscopical Society, Journal of Microscopy, American Monthly Microscopical Journal, Zeitschrift für wissenschaftliche Mikroskopie, Zeitschrift fur angewandte Mikroskopie.

Is such publication justified by necessity? It might be urged that these organizations should all change the titles of their publication. It would of course be impossible to limit them at once to methods as the writer suggests. The difficulty I take it is chiefly in the name. But who can suggest a better name for these organizations? Many have tried and have fallen back on their old name. The name any way plays a very insignificant part in the question as compared with the importance of having zoological and botanical subjects brought into the meetings. It is, it seems to me, very desirable to cultivate a taste for investigation in natural science in the minds of members of these societies. It is one of the most effective propaganda of which I know. It must be remembered that there are many workers now in biology in America and we know very well that the GAZETTE cannot give space to all the articles it would. Other botanical journals find their columns unequal to the demand for space. Every year the volume of matter published upon biological subjects increases. With this increase the labor of investigating increases but this should never be allowed to discourage the publication of investigations. It is a neces-

sity both from the point of view of the investigator and from the point of view of the increasing multitude of readers that channels of publication should increase. Few of these channels have a more definite function to perform than the American Microscopical Society. Whether it is efficient in performing that function those who read its pages are alone able to tell. Its co-laborer, the GAZETTE, will be the last I am sure to discourage it in its mission.—W. W. ROWLEE, *Cornell University.*

Nature of the binary name.

In the January issue of the GAZETTE Professor Bailey has urged against the essential permanency of the specific name an argument of so much originality as to be worthy of careful consideration. He presented the same idea some five years since,[1] and I remember then regarding it as an argument needing to be answered; yet I do not recall having read anywhere a word of comment upon it. The gist of the Professor's argument lies in these two interrogations: "Is nomenclature monomial or binomial? Is *bullata* or *Carex bullata* the name of a sedge?" The two forms of expression are, of course, but the abstract and the concrete, respectively, of one thought. In other words, the query is but one; and its strength as an argument resides in the perfect confidence with which a certain one of two conceivable answers is expected. The propounder of this forceful question appears firmly to believe that any and every botanist gifted with ordinary human intelligence must answer: "*Carex bullata* undoubtedly, and not merely *bullata*, is the name of a certain sedge." If this be, what Professor Bailey so confidently believes it, the only rational answer; if it be the correct answer, the argument is strong enough utterly to discredit the practice of treating the retention of the earliest specific name as obligatory under the law of priority.

But, if what the author of the argument deems rationally out of the question be not only possible but defensible; if the affirmative answer to one of the questions does not necessarily involve the negation of the other; if both *bullata* and *Carex bullata* are names of a certain sedge, then the argument, so specious at first glance, is weakened, if not invalidated. And I shall venture to assert, having in mind the continual practice of all botanists, that, under certain limitations, *bullata* alone is the entirely sufficient name of a sedge. Professor Bailey will not dissent from such a proposition as this, that he could lecture for an hour, or for five hours, upon a certain group of sedges, discussing, the while, any number of species from a half-dozen to several hundreds, without any chance of indefiniteness or ambiguity as to the plants, and all this without using any but the specific names; never once, by any necessity of the situation, employing before his hearers the generic term *Carex*. Nor is this instance merely a supposititious one; precisely this usage being so exceedingly common that any botanist, at least upon a moment's reflection, must realize the universal prevalence of it. We do not, as a rule, make extensive use of anything but the specific names, in oral converse, no matter what the genus under consideration may be, unless it should be a monotypic one, in which

[1] BOT. GAZETTE **16**: 215.

case we as universally ignore the specific name, making the generic the mononomatic appellation of the species. What botanist, having occasion to speak of monotypes, like *Calypso* or *Arethusa* for example, employs the full binary name? There is no need of it; and, in an age less formal and pedantic than ours, no specific name would be assigned to monotypes, even in books and catalogues. The thing is wholly useless; at best a sort of rhetorical flourish appended to that simple term—that "monomial," to use, but not to approve a word so constructed—which usage makes the essential name of that species of plant. The name is even perfectly competent to distinguish that plant from all others; and so, in this instance we have a well warranted answer to Professor Bailey's question quite unlike any he deemed possible; a name of one term which is perfectly competent, and every way sufficient, to answer every demand but that of pedantry.

But, however extensively used the specific name as mononomatic may be, we can never say of this that it is the name by which a species may be absolutely distinguished from all other species of plants. So much must certainly be conceded to Professor Bailey. Nevertheless, it seems to me that he must feel himself compelled to admit that it has been just this extremely common oral treatment of the specific name as *the name* of a species which has led to the widely prevalent practice or retaining the first specific name under whatever genus; a practice which many have contended for as obligatory under the principle of priority, and which the most eminent and scholarly botanists of all ages have adhered to. Let me insist also upon this; that, in looking for fundamental principles, we are forced to make inquiry into oral usages; for these are everywhere anterior to written usages, and may have much to teach us.—Edw. L. Greene, *Washington, D. C.*

NOTES AND NEWS.

THE BELIEF that the nucleolus is not a permanent cell organ has been further confirmed by the observations of F. Rosen (*Bot. Centralbl.* 65: 115) in his studies of the root tips of Pisum, Phaseolus and Zea.

THE METHOD by which underground shoots gradually sink in the soil is said by A. Rimbach (*Ber. Deutsch. Bot. Gesell.* 13: 141) to be due to the power of forming contractile roots, especially when they are young.

IN HIS STUDY of the "oil tubes" of Umbelliferæ C. Van Wisselingh (Arch. Néerl. Sci. Ex. et Nat. 29: 199) concludes that the characteristic substance of the walls is neither suberin nor cutin, but an allied substance which he names "vittin."

DARWIN'S explanation of the nyctitropic position of leaves, that it is a protection against nocturnal radiation, has been controverted by E. Stahl (*Ber. Deutsch. Bot. Gesell.* 13: 182), who sees in the position a device to promote transpiration in the night and early morning.

A PATHOGENIC YEAST has recently been studied by Dr. H. Tokishige of Tokio (*Centralbl. f. Bak.*, 1te Abt., 19: 105). It is the cause of an infectious skin disease of horses in Japan. In artificial cultures it produces spores, and is named by the author, *Saccharomyces farciminosus.*

MR. JOHN K. SMALL has described (*Bull. Torr. Bot. Club*, Jan.) two new genera of Saxifragaceæ. *Jepsonia* is based upon *Saxifraga Parryi* Torr. and includes also *S. malvaefolia* Greene; and *Saxifragopsis* is based upon *Saxifraga fragarioides* Greene. Both genera are illustrated.

IT IS ANNOUNCED that the herbarium of the late Mr. Redfield, bequeathed by him to the Philadelphia Academy of Science, is about to be sold by that institution to form a nucleus for the Redfield fund of $20,000, to be used for the benefit of the botanical section of the Academy.

IT IS OF INTEREST to note that the protest against the old category of "parallel-veined" leaves is growing. L. Gabelli (*Malpighia* 9: 356) has pointed out that the greater number of cases so referred are but instances of palmate venation modified by the ribbon-like form of the leaf.

THE ANTHER of Loranthaceæ has been investigated by Van Tieghem (*Bull. Soc. Bot. France* 42: 363) with some interesting results. The number of "pollen-sacs" is remarkably variable, ranging from one to an indefinite number. It would be of interest to know whether "pollen-sacs" refer to the microsporangia, or to the "pollen-sacs" of ordinary usage.

THE "LATENT LIFE" of the seed has been a matter of much curious speculation. C. De Candolle has come to the conclusion (*Arch. Sci.*

Phys. et Nat. 33: 497) that it is a case of "suspended animation." It is hard to imagine such a thing as "potential life," but easy to conceive of the necessary life exchanges being reduced to so low an ebb and flow as to be imperceptible.

THE EDITORSHIP of Queen's *Microscopical Bulletin* will hereafter be in the hands of Mr. Albert S. Baker. Mr. Edward Pennock, who has been the able editor of the *Bulletin* since its inception twelve years ago, has severed his connection with the firm, in order to establish a new depot for microscopical supplies. The journal will be continued without material change in form.

BULLETIN DE L'HERBIER BOISSIER for Dec., 1895, and Jan., 1896, contain papers of unusual interest to American botanists. In the former, the Mexican collection, known as *Plantæ Selerianæ* and determined by numerous specialists, is presented in part. In the latter, Renauld and Cardot discuss certain species distributed in their *Musci Americæ Septentrionalis Exsiccati.*

THE EXPLORATION of Central Africa is bringing to light many plants of great interest. Splendid forests of what are called "cedars" have been discovered on the Mlanje plateau, in British Central Africa. This "cedar" is a *Widdringtonia*, somewhat distantly allied to the cypresses. It seems now as though it is an isolated plant, somewhat like the Sequoias of our own Pacific slope.

NEW TERMS are constantly arising in botanical literature. One of the latest is "heterotopic," applied by F. X. Gillot (*Bull. Soc. Bot. France* 41: 16) to those plants which are occasionally found on soils apparently very different from their normal substratum. The difference, M. Gillot shows, is more seeming than real.

THAT THERE IS NEED of some reconstruction of our views as to the development of the "embryo-sac" structures is evidenced not only by the fact that *Casuarina* has no antipodal cells, which seems to be true also of certain amentaceous genera, but now by the fact that *Corylus*, announced to be chalazogamic by Nawaschin, shows well-developed antipodals before the appearance of the egg-apparatus.

MR. HEMSLEY, in *Gardner's Chronicle* (Jan. 11th), gives a brief account of recent botanical discoveries in New Zealand, where botanical activity is very great. Hooker's *Handbook* of thirty years ago is the only complete account of the flora, but the *Transactions of the N. Z. Inst.*, now having reached its 27th volume, has been made the record of botanical discovery. In it about 550 new species of flowering plants have been described, but among them all there is but one new genus, and that an inconspicuous one.

THE VALUABLE COLLECTIONS of Mr. J. B. Ellis of Newfield, N. J., have been purchased by the New York Botanic Garden, together with a large part of his mycological library. It is a very large herbarium, and one of the most valuable in the country, containing numbers of type specimens, and rich in material illustrating the distribution of species. The Garden is to be congratulated upon securing so important a collection of fungi. It will shortly be moved to a fire-proof building in New York city to await the completion of the Museum Building at the Botanic Garden.

PROF. ALBERT N. PRENTISS, for many years professor of botany at Cornell University, has been compelled by prolonged ill health to resign his professorship. He has been elected *Professor Emeritus* by the Board of Trustees. The vacancy thus caused has been filled by the promotion of associate professor Geo. F. Atkinson to the professorship. Assistant professor W. W. Rowlee has been promoted to the highest grade of assistant professor. E. J. Durand, Sc. D., has been appointed instructor in botany, and K. M. Wiegand assistant. The courses of instruction have been reorganized and beginning with the next college year advanced and graduate courses in botany will be offered.

THE RECENT "Culver gift" of one million dollars to the University of Chicago for biological endowment has resulted in the establishment of a Department of Botany, in which Dr. John M. Coulter has accepted the head professorship. A large building, to be known as the "Hull Botanical Laboratory," has been planned, and its erection will soon be begun. The four stories of this building will contain ample space for lecture rooms, libraries, laboratories, and private research rooms for morphology, physiology, and taxonomy. Above the fourth story a large roof greenhouse will supply an abundance of living material under all conditions. As the building will not be completed before April of 1897, the full botanical staff will not be organized before the fall of that year.

IN A RECENT number of *Anatomischer Anzeiger*, Professor Conway MacMillan criticizes the statements of Dr. Beard regarding the resemblance between metazoan and metaphytic reproductive processes. The statement that "the whole of the cells of the gametophyte must be looked upon as morphologically equivalent, some becoming differentiated as vegetative organs by sterility, others retaining the primitive character of becoming conjugating gametes," is regarded as specially objectionable. It certainly seems to follow the morphological idea of Bower with reference to the sporophyte. Professor MacMillan homologizes metazoan and metaphytic reproduction by considering "the metaphytic coenogenetic spore a homologue of the metazoan blastomere." He does not see alternation of generations in animals as in plants, the reason of which he suggests lies in the "general automobility of sexual animals and the as general non-automobility of sexual plants." He concludes that "sporophytization is as essentially a plant character as cephalization is an animal." "The one is an expression in the organism of the static life, the other of the dynamic."

MR. J. E. HUMPHREY, in *Annals of Botany* (Dec.), discusses "some constituents of the cell." The problem of the nucleolus is taken up, and Zimmermann's view that it is a permanent organ combatted. Strasburger contends that it disappears or at least diminishes during nuclear division and is frequently ejected into the cytoplasm, and has proposed the theory that it furnishes the material for the spindle-fibers. Humphrey, in examining abundant material, confirms Strasburger as to the usual disappearance of nucleoli during karyokinesis and their reappearance in the daughter nuclei. All this, of course, militates against the idea that the nucleolus is a permanent organ. Humphrey

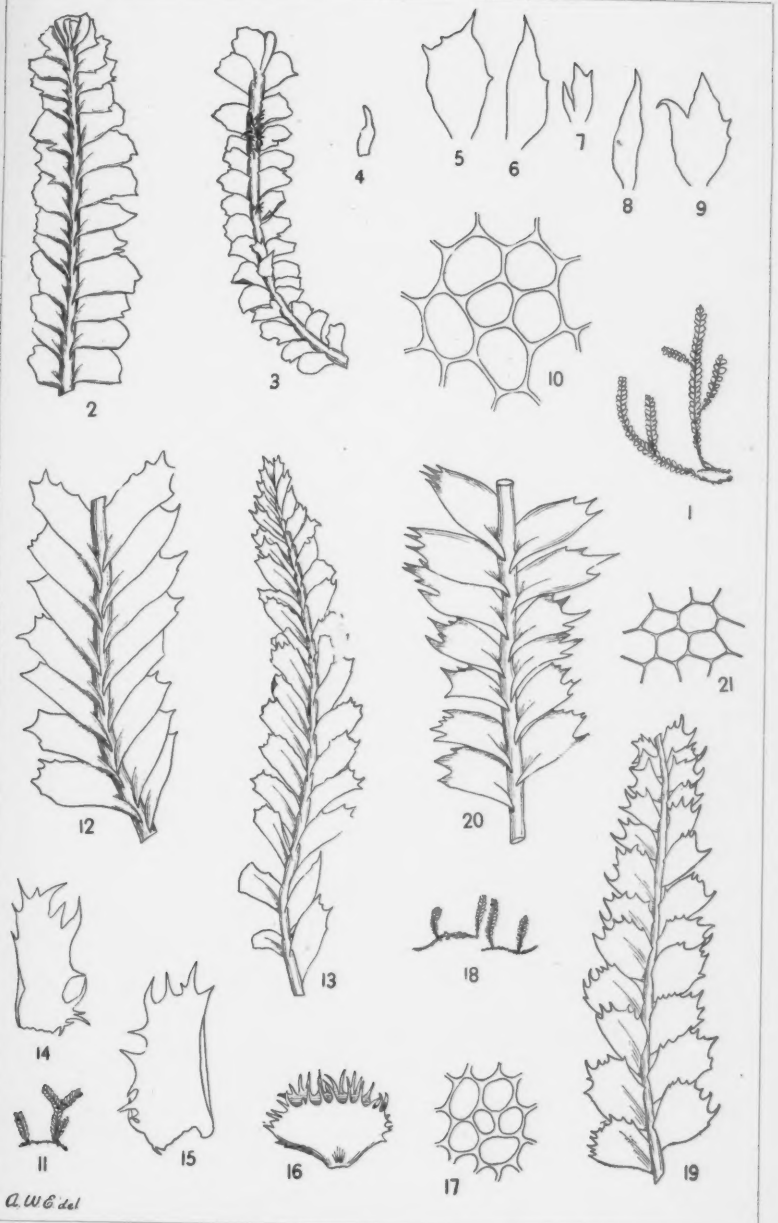
has also examined Zimmermann's "sickle-stage" of the nucleolus, in which it occurs flattened against the nuclear membrane. Zimmermann has connected this phenomenon with the reduction of the chromosomes, and therefore finds it only in the first division of the spore mother-cell. Humphrey finds it in ordinary vegetative cells and not at all in the spore mother cells, and when found it is better explained as due to displacement by the unequal penetration of the fixing fluid, and hence of no significance.

The "centrospheres" are also discussed, and the fragmentary character of our knowledge concerning them emphasized, and also the difficulty of observing them in plants as compared with animals. All additional evidence, however, goes to show their uniformity, their permanent character, and their fundamental importance.

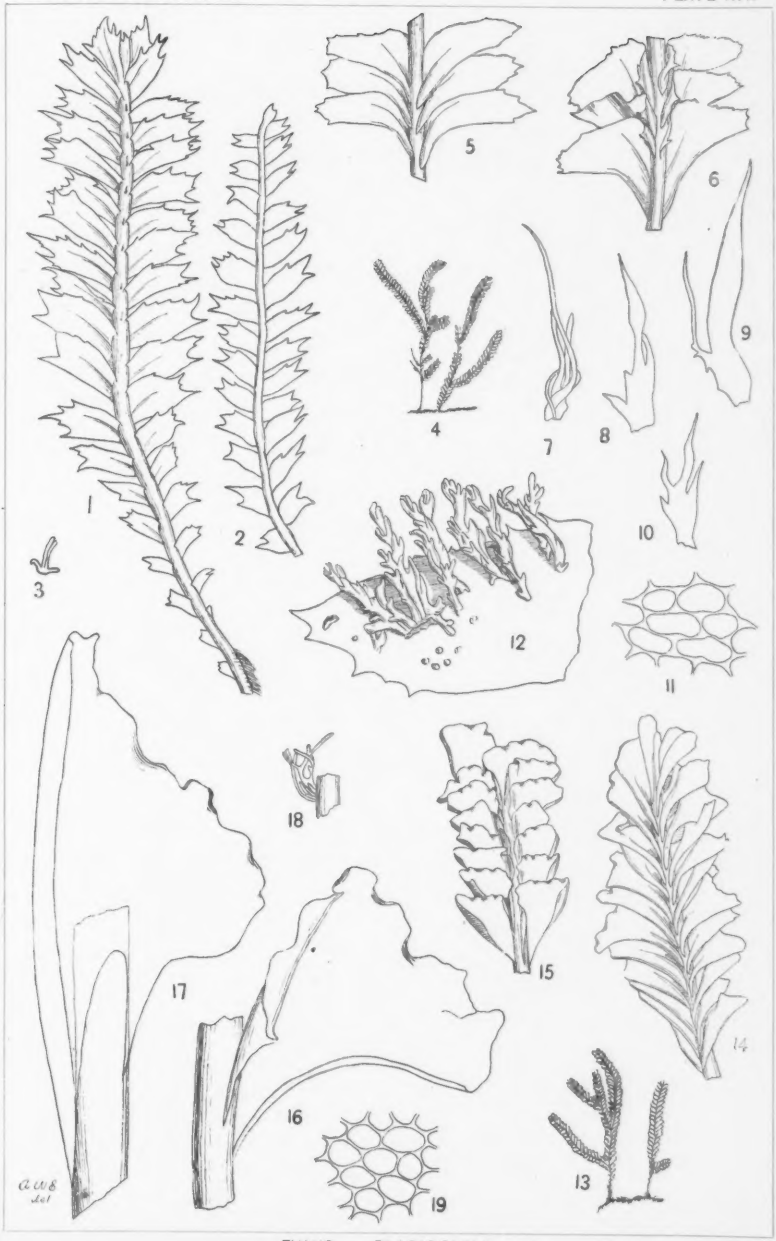
M. P.-A. DANGEARD, in *Le Botaniste* (Jan. 10th), has published a very interesting illustrated paper upon the parasites of the nucleus and those of the cytoplasm.

ENGLER'S *Die natürlichen Pflanzenfamilien* is rapidly approaching completion. Parts 126–128 are now before us, containing besides several small families the beginning of *Labiatæ* by Briquet.

THE DIVISION OF FORESTRY has issued as its tenth bulletin "an elementary discussion of the characteristics and properties of wood," by Filibert Roth, special agent in charge of timber physics. It is the first publication of its kind in English, in systematic and available form, and with special application to American timber.



EVANS on PLAGIOCHILA.



EVANS on PLAGIOCHILA.